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EU consumers' evidence on the innovation and environmental impacts from possible common charger regulation forcing a single device-end connector type

CLIENT: APPLE
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EXECUTIVE SUMMARY

Would common charger regulation benefit EU consumers, given their preferences for innovation and convenience?

Today's smartphones, tablets, and other portable electronic devices feature only a handful of alternative types of device-end connectors used for attaching charging cables. Product design is the outcome of a dynamic and competitive market, where consumers have large power to switch between different device producers (as the ups and downs in manufacturers in the last decade have shown). In turn, manufacturers compete with one another by designing devices with the features (including choosing device-end connector types) that consumers are likely to find most valuable – and ultimately consumers choose according to their evolving preferences.

Device-end connector types have not always been so limited in number. A decade ago, following a booming growth of mobile phone take-up across the EU, the number of device-end connector types on the market was far higher. As reported by the EC DG GROW, more than 30 different types of charger were on the market, causing inconvenience to the consumer and unnecessary electronic waste.[1] As in any vibrant market, consumer inconvenience leads manufacturers to find solutions to attract and win consumers' favour. Market forces have tackled the proliferation of charger types, as manifested in an industry agreement backed in a MoU supported by the European Commission in 2009. This market evolution has successfully reduced device-end connector types, consumer inconvenience and unnecessary environmental burden. Three alternatives (USB Micro Type-B, USB Type-C, Lightning) now serve most devices. Additionally, almost all chargers feature USB connectors, allowing broad interoperability to use detachable cables to charge phones, tablets, laptops, smartwatches and other portable electronic devices with the same charger.

Still, some theoretical concerns have been raised that a device market with three alternative connector types may inconvenience consumers too much and that the existence of three alternatives may per se cause large environmental harm by causing excessive use and production of device cables. A precise empirical research question follows: to what extent would a regulatory requirement to reduce the three alternatives to one benefit consumers?

The answer derived from analyzing empirical evidence is that a single connector-type mandate would harm consumers significantly more than it would help either them or the environment.

Evidence from a survey of European electronic device users shows that having three device-end connector types rather than one is **not a concern in reality** since consumers:

- have, on average, close to **1 cable in regular use for each device** (5.6 cables and 5.4 mobile devices per household, plus 0.4 cables not in regular use).
  - **51% of households already have a single connector type across all of their mobile devices**, so an EU single connector mandate would not impact them

[1] European Commission, *One mobile phone charger for all campaign*, available at: https://ec.europa.eu/growth/sectors/electrical-engineering/red-directive/common-charger_en

  - for the **49% of households whose devices rely on different connector types, less than half would likely reduce their cable demand/use** if a single connector type were required across all mobile devices
  - Nearly **90% of all EU households charge multiple devices at the same time** at least sometimes per week
  - Only **0.4% of EU consumers regularly experience any significant issue** in being unable to charge their phone due to an available **charging cable being incompatible** with their own phone
  - out of all households, **only 20% said they are likely or very likely to reduce** the number of charging cables they have
- would only in small part reduce demand/use of cables if a regulatory-mandated single connector type is forced: an **average reduction from 5.6 cables to 4.9 cables per household, at most** (a 14% decrease)
  - given the CO_2 impact of each cable and the official € trading value for CO_2, the likely decrease yields **environmental benefits limited to €13 million (**NPV over seven years) – in comparison, the environmental cost of CO_2 emissions from the EU (excl. the UK) passenger car traffic in 2017 was €6 billion

The survey evidence is clear: consumer demand for chargers would decrease only marginally if a single device-end connector type is mandated for all mobile devices. The intuition is that consumers today use multiple chargers mainly because they value the convenience of charging multiple devices at once (e.g. in the evening) or having multiple chargers/ cables available at different locations, not because they have devices with different connector types. Short of forcing consumers to forego convenience and change their ways of life by rationing access to charging cables, a 'Common Charger' policy mandating a single connector type cannot reduce the amount of cables that consumers use. There is no significant policy case based on consumer convenience supporting a Common Charger rule forcing a single device connector type.

The market-based choice of device-end connector type has struck a careful balance that has enabled and fostered innovation and improvements in devices, chargers, cables and device-end connectors – all to the benefit of consumers. Several such advancements are embodied in the USB Type-C connector type, which many manufacturers use for some or all of their devices – depending on their view of what connector type is best for particular devices and their expected usage. On the other hand, forced standardisation can curtail or slow innovation. This may in theory be acceptable in markets where there is no recent evidence of past innovation or where consumers do not value future innovation. In contrast, consumers in the mobile device market do place a significant value on the innovative connector type features that the market has delivered over time – as exemplified by the Lightning and then USB-C connector types. The survey evidence shows that EU consumers:

- value current state-of-the-art connector types' features as a key benefit compared to connector types from previous generations, demonstrating that market forces have delivered large value by the past innovation waves – **€14 billion of estimated consumer value**, accumulated between the period 2012-2018.
- clearly express a desire to see further innovation in the future; such innovation could be blocked or significantly delayed if a regulatory-mandated single device connector type is imposed – a **€1.5 billion estimated future consumer harm** (NPV over seven years)

Forcing a single Common Charger device-end connector standard applicable to the EU would be a trade-relevant measure that could separate the EU Single market from the global market. Even if the market for chargers is characterised by a handful of device-end connector types, unilateral regulatory action to introduce a single EU Common Charger risks creating a non-tariff barrier to trade around "fortress Europe", which can unduly limit or delay the extent of supply / choice available to EU consumers.

In conclusion, based on the evidence gathered, the consumer harm from a regulatory-mandated single connector type (at least €1.5bn) significantly outweighs any associated environmental benefits (€13m). On this basis, given the centrality of consumer benefits in the policy evaluation, it is unlikely that a Common Charger initiative forcing a single connector type would achieve a positive socio-economic outcome. Even a well-intended policy runs a clear risk of ending up with a significant unintended impact due to the large consumer harm from stifling or delaying innovation in device and connector type design, which consumers have highly valued.

EVIDENCE FROM NEW SURVEY OF EUROPEAN CONSUMERS' USE OF MOBILE DEVICES AND CHARGING CONNECTORS

Copenhagen Economics

We have asked European consumers who use mobile devices: Smartphones Tablets Other small electronics

TODAY

EU consumers surveyed have **1.04 charging cables per device** (1.1 including cables not in use) [1]

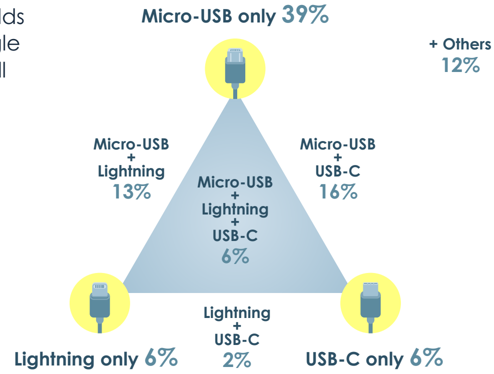
The average EU household has...

5.4 mobile devices

5.6 charging cables

+ 0.4 charging cables not in regular use

51% of EU households already have a single connector across all their cables [2]



Nearly **90%** of survey respondents charge multiple devices simultaneously at least some times per week [3]

The realised consumer value (2012-2018) thanks to the **past introduction of innovative connectors:** [4]

€14 billion

Lightning

USB-C

Innovation achieved so far

IF A SINGLE DEVICE-SIDE CONNECTOR IS MANDATED...

...CONSUMER DEMAND

Only **21%** of EU households said they would likely or very likely reduce their total number of cables in the case a single connector is introduced [5]

Very likely	Likely	Neither likely or unlikely	Unlikely	Very unlikely	Already have one single connector
7%	14%	11%	9%	7%	51%

Across all EU households (both those currently with on single connector-type and those currently with one single connector-type), consumer demand for cables could at most fall by **14%** [6]

Before 5.6

After 4.9

–14%

...ENVIRONMENTAL EFFECT OF CONSUMER DEMAND

Therefore, the environmental benefits would be limited to **€13 million** (NPV over seven years), based on the CO_2 impact from cable production linked to the change in EU consumer demand [7]

...INNOVATION IMPACT

Very interested	Interested	Somewhat interested	Not interested	Not interested at all
20%	33%	33%	7%	7%

85% of EU consumers are interested in future innovation and improvements in the charging experience [8]

A regulatory mandated single existing connector type risks blocking or **delaying future connector innovation**

A delay in innovation would lead to an estimated loss of consumer value of **€1.5 billion** (NPV over seven years), while blocking innovation completely would lead to an impact nearly 10 times larger [9]

Future innovation at risk

...IN CONCLUSION

No significant consumer convenience evidence supporting mandating a single device-side connector

As a result, **environmental benefits** would be limited and several orders of magnitude smaller than the **innovation harm**

Environmental benefits
+ €13 million

Innovation harm
– €1.5 billion

Sources: [1] EU consumer survey [2] EU consumer survey [3] EU consumer survey [4] EU consumer survey; mobile market sales [5] EU consumer survey [6] EU consumer survey [7] EU consumer survey; Eurostat demo-graphic data; official price forecast for EU traded CO2 [8] EU consumer survey [9] EU consumer survey; mobile market sales forecast

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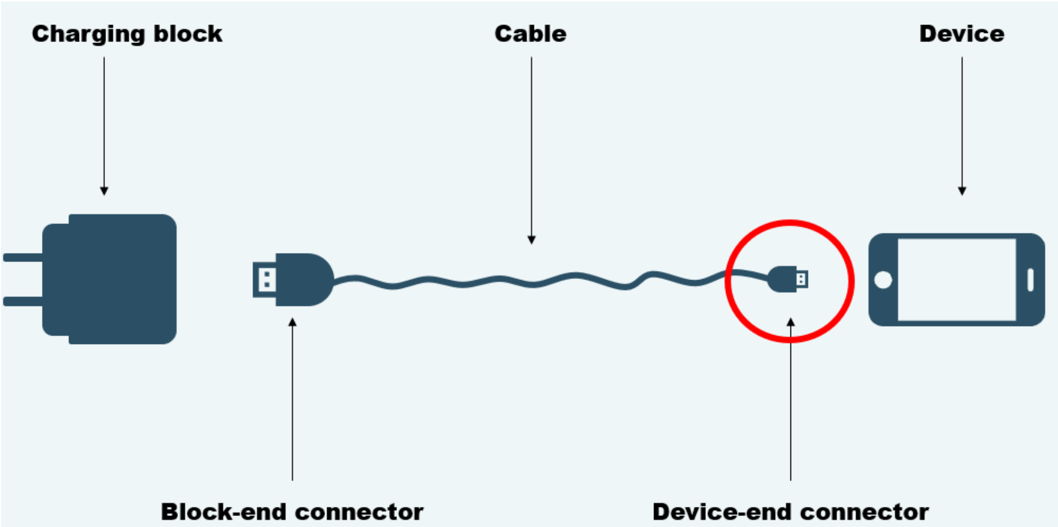
CHAPTER 1
A DECADE OF POSITIVE MARKET DEVELOPMENTS FOR CHARGERS

The European Commission is considering adopting legislation to establish a 'common charger for mobile telephones and other compatible devices' in the EU – its Standard Chargers for Mobile Phones Initiative or, as we will refer to it throughout this report: *the Common Charger initiative*. The objective of the Common Charger initiative is to create a situation where consumers in the EU can use any charger (read: charging / connector cable) for any brand of mobile phones and, possibly, other types of mobile devices with compatible electric current requirements.

Figure 1
Illustration of different components of a charger



Source: Copenhagen Economics

We contribute to the analytical basis for the Common Charger initiative with this report, analysing the impacts of the most intrusive scenario: regulatory action that mandates all mobile devices in the EU Single Market to be chargeable with only one specific type of cable and device-end connector (cf. Figure 1), without adaptors. Figure 2 shows the three types of device-end connectors that currently drive the market and are indicated in the Inception Impact Assessment[2] (IIA) for the initiative as the potential chosen device-end connector for the EU Common Charger: The USB Micro Type-B, the USB Type-C and Apple's Lightning connector.

[2] European Commission, 2018, *Inception Impact Assessment: Common chargers for mobile telephones and other compatible devices*, Ref. Ares(2018)6473169 – 15/12/2018.

Figure 2
The three most common types of device-end connectors currently in the market and that are under consideration in the Inception Impact Assessment

Source: https://www.ipitaka.com/blogs/news/everything-you-need-to-know-about-smartphone-cables.

Specifically, we contribute to the existing and forthcoming literature and debate by adding novel insights into the consumer-side impacts of a Common Charger initiative, complementing previous research that has focused on the supply-side impacts. The report is not a full impact assessment considering every relevant impact that a Common Charger reform is likely to have on the economy and society. Instead, we focus on the likely demand-side impacts on consumer value from future charger innovation, changes to consumer behaviour and the resulting environmental impact.

The rationale for this approach is straightforward: the stated primary objective of the Common Charger initiative is to increase consumer convenience, and we will shed light on the value consumers assign to improvements and innovation of chargers and of the charging experience (**chapter 2**). We provide a brief overview of the potential that the Common Charger initiative creates a non-tariff barrier to global trade, thus balkanising the global market for mobile devices (**chapter 3**). The Commission also expects that the initiative will lead to a reduction in charger production and e-waste. As production and e-waste creation is determined by consumer demand for chargers, we shed light on how consumer demand is likely to change with a Common Charger (**chapter 4**).

Thus, consumer convenience, value and behaviour take centre-stage throughout the report, as it has done in the market developments over the past 10 years, of which we give a brief overview in the remainder of this chapter.

There are pros and cons of regulatory intervention. On the one hand, enforcing a one-standard policy changes the market dynamics and can lead to less innovation and solutions that do not meet consumer needs as well as what a free market can deliver. On the other hand, enforcing a one-standard policy could in theory increase consumer convenience and reduce environmental impacts through reduced production quantities.

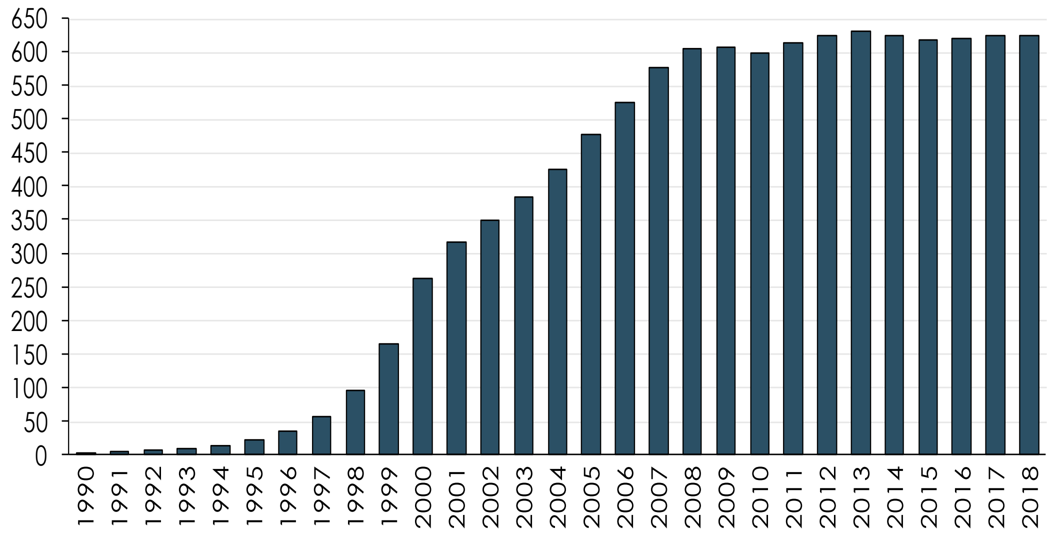
Hence, it is necessary to assess the balance between costs and benefits of regulatory intervention. The case for regulation in the market for chargers is strong if the following factors are present:

- The market is fragmented with many different charging solutions and there are no signs of improvement
- There are no differences in consumer preferences for devices and charging solutions
- There are barriers to use or access the open standard
- Chargers create a lock-in effect on consumers' choice of mobile devices

1.1 BILLIONS OF DEVICES AND ONLY THREE DEVICE-END CONNECTOR TYPES

From the early 1990s until the late first decade of the 21st century, the number of mobile phone subscriptions in the EU exploded from 3 million to 600 million. Since then, the number of mobile phone subscriptions has stabilised and currently stand at around 630 million, cf. Figure 3.

Figure 3
Mobile phone subscriptions in the EU
Millions of subscriptions



Note: The numbers include both feature phones and smartphones.
Source: The World Bank

In addition to the growing usage of smart phones, other types of chargeable mobile devices have been introduced to the market and grown in popularity, such as tablets, e-readers, portable speakers, GPS navigators, cameras and wearables (e.g. smart watches and other activity trackers), to name a few.

It is reported that there are currently approximately 4 billion *active* Android and Apple devices around the world (including e.g. smartphones, laptops, tablets, watches, etc).[3, 4] For all those devices, there are three types of device-end connector types prevalent in the market (cf. Figure 2):

- the USB Micro Type-B (launched in 2007)
- the Lightning (launched in 2012)
- the USB Type-C (published in 2014, launched in 2015)

1.2 BEFORE THE MOU: THE WILD WEST OF CHARGERS

Around the time when the number of mobile phone subscriptions first passed the 600 million mark in the EU around 2008-2009, there were at least 30 different types of chargers for those phones.[5] Most phone producers used their own proprietary charger, making it unlikely that one person's charger could be used for another person's phone.

Figure 4
Selection of legacy device-end connectors

Note: Connectors: SonyEricsson K750, Nokia 3.5 mm, Samsung Old 20-pin, Samsung New 20-pin, LG KG90, USB Mini, USB Micro, PSP, Nokia 2.0 mm
Source: https://www.elvvs.dk/p/universal-stroemadapter-multiple-charger-cable-micro-usb-mini-usb-psp-nokia-3-5-mm-nokia-2-0-mm-sony-905054/?gclid=CjwKCAjwldHsBRAoEiwAd0JybS0TYzlR5C4nOT6eQ4Se-2Un-WcPsww5rHnNh7Odq1gnrx3b9TE9KbhoCTfgQAvD_BwE

It was not uncommon that different phone models from the same producer had different, mutually incompatible, chargers. Thus, even if a consumer stayed faithful to one mobile phone brand, he or she would often find that each new phone required a different type of charger, making it impossible to reuse existing chargers a consumer had available.

Specifically, it was the shape, form and functionality of the device-end connector that made it impossible to reuse existing chargers. That is the part of the charger that connects the phone to the cable, cf. Figure 1.

3 Android Police, 7 May 2019, *There are now more than 2.5 billion active Android devices*, available at: https://www.androidpolice.com/2019/05/07/there-are-now-more-than-2-5-billion-active-android-devices/.
4 The Verge, 29 January 2019, *Apple says there are 1.4 billion active Apple devices*, available at: https://www.theverge.com/2019/1/29/18202736/apple-devices-ios-earnings-q1-2019. At least 900 million of the active devices are iPhones, and the remaining devices range from Macbooks, iPads, Apple TVs, iPods and Apple Watches.
5 European Commission, One mobile phone charger for all campaign, available at: https://ec.europa.eu/growth/sectors/electrical-engineering/red-directive/common-charger_en.

In addition, most cables were permanently attached to the charging blocks, so with every new phone came a need for a new charging cable and charging block. If the charging cable got damaged or lost, consumers had to buy a new charging block and cable all-in-one.

The size and weight of charging blocks meant that it was inconvenient to carry them around, so whenever a phone needed charging outside the user's home (or workplace) one likely had to wait until returning home. If there was an available charger belonging to someone else around, it was unlikely to fit your phone.

Figure 5
Old type of charger with a heavy charging block and non-detachable cable

Source: https://www.colourbox.com/image/phone-black-charger-isolated-on-white-background-image-1279232

This situation led the manufacturers of mobile phones, the industry organisation DigitalEurope, and the European Commission, to sign a Memorandum of Understanding (MoU) on harmonising chargers for mobile phones, in 2009.[6] The original ten signatories were:

- Motorola
- LGE
- Samsung
- RIM
- Nokia
- SonyEricsson
- NEC
- Apple
- Qualcomm
- Texas Instruments

Later in 2009 and early in 2010, the following producers also signed the MoU:

- Emblaze Mobile
- Huawei Technologies
- TCT Mobile
- Atmel

[6] MoU regarding Harmonisation of a Charging Capability for Mobile Phones, 5 June 2009.

Under the MoU, producers committed themselves to ensure that all new mobile phones placed on the market from 2011 and onwards would be compatible with the USB-Micro Type B device-end connector. At the time of signature, the USB-Micro Type B was the most modern type of USB connector, launched in 2007.

In addition, the MoU stated that no technical or regulatory steps should be taken that would fragmentise the global market for mobile phones, nor should the MoU preclude innovation in the markets for mobile phones or external power supplies.

Figure 6
USB Micro Type-B device-end connector

Source: https://www.colourbox.com/image/new-micro-usb-connector-the-new-2007-standard-for-cell-phones-image-1502736

1.3 AFTER THE MOU: HARMONISATION

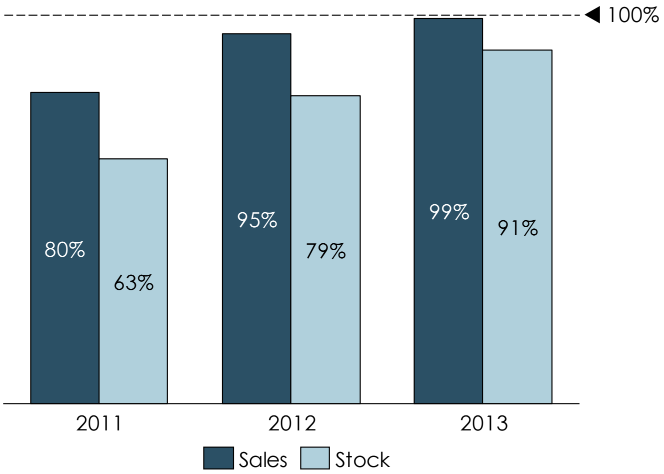
As it turned out, the MoU became a success. Some producers decided to comply with the MoU by designing their phones with a USB-Micro Type B receptacle. This was the choice of most producers of smartphones using the Android operating system. Some producers, most notably Apple, complied with the MoU by offering consumers adaptors that enable the use of cables with a USB-Micro Type B device-end connector while maintaining a proprietary receptacle on the device (adaptors were launched in 2012, at the same time that Apple launched the Lightning connector, which is still used on iPhones, some iPad models and other products).

Figure 7
Lightning device-end connector and USB Micro Type-B to Lightning adaptor

Source: https://www.apple.com/shop/product/MD820AM/A/lightning-to-micro-usb-adapter

In an official report for the European Commission, it was found that 99 per cent of all smartphones sold in the EU in 2013 complied with the MoU, an increase from 80 per cent in 2011, cf. Figure 8.[7] This meant that the stock of smartphones in the EU that were MoU-compliant – i.e. could be charged with a USB Micro Type-B cable, either with or without and adaptor – increased from 63 per cent to 91 per cent in only two years.

Figure 8
Share of smartphones complying with the MoU, 2011-2013
Per cent of sales and stock, respectively



Note: Sales refers to the number of smartphones sold during the year, while the stock refers to the number of active smartphones on the market.
Source: Copenhagen Economics based on RPA, 2014, *Study on the Impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*, p. i.

[7] Risk & Policy Analysts (RPA), 2014, *Study on the Impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*, prepared for the European Commission (DG Enterprise and Industry).

It was noted that "*...the number of different charging connectors on the market has declined substantially over the period of the MoU and the vast majority of handset owners now have an MoU compliant phone, which enables many to charge their phones using chargers of friends, colleagues, etc.*".[8]

Furthermore, the report pays tribute to the success of the voluntary approach to harmonisation, by stating that "*The chosen method of bringing about harmonisation (a voluntary agreement facilitated by the European Commission, together with the development of a technical standard) has thus proven to be highly effective in terms of increasing harmonisation of mobile phone charging in the EU and improving consumer convenience*".[9]

Interestingly, the report also notes that very few consumers that use mobile phones with a proprietary receptacle (i.e. iPhone users) had chosen to purchase adaptors.[10] Thus, while the MoU fostered the availability of such adaptors, it turned out that few consumers felt the need to have them. In other words, consumers with phones using a proprietary device-end connector do not seem to be particularly bothered by the fact that they cannot use USB Micro Type-B charging cables.

However, improvements and innovation in the market for chargers were not limited to the device-end connectors. Although it was not a part of the MoU or any other explicit agreement among producers, almost all charging cables that are placed on the market today are detachable from the charging block.

Interestingly, unlike the developments on the device-end connector side, there is essentially complete homogeneity on using USB Type-A charging block-end connectors.[11] For example, while Apple has chosen to offer adaptors for the device-end connector to maintain the Lightning receptacle on their devices, their Lightning cables have USB Type-A block-end connectors (and, recently, also USB Type-C block-end connectors, see footnote 11).

Figure 9
A detachable charging cable and block with a USB Type-A block-end connector

Source: https://www.imediastores.com/product/original-apple-5w-usb-power-adapter/

[8] Ibid, p. iii.
[9] Ibid.
[10] Ibid, p. 64.
[11] In the past few years, some producers also offer consumers the chance to buy charging blocks and cables with a USB Type-C connection between charging block and cable which enable faster power and data transfer speeds

The market development of detachable cables with homogeneity on the type of charging block-end connector has greatly improved consumer convenience, as it is now possible to use any charging block regardless of the cable's device-end connector. In addition, cables with a USB Type-A block-end connector can also be plugged into other types of power sources than charging blocks, such as laptops, and specific USB Type-A power outlets found in e.g. aircraft, trains and buses.

Figure 10
USB Type-A power outlet on aircraft

Source: https://www.colourbox.com/image/inserting-usb-flash-drive-into-socket-of-monitor-in-airplane-image-32256577.

It is a prime testament to the ability of the invisible hand of the smartphone market to reach the optimal level of harmonization that balances all relevant aspects and factors that create value for consumers. This is especially important given that charging blocks typically are larger and heavier than cables, leading to a larger carbon footprint and are more inconvenient to carry around, than cables.

The original MoU expired in 2012 but was subsequently extended twice by mobile phone producers signing letters of intent in 2013 and 2014. The letters of intent declared that the signatories committing to continue to supply the EU market with MoU-compliant chargers.[12] Though the last letter of intent expired in 2014, the EU (and indeed the global) market has nonetheless continued to be supplied with the few types of chargers and cables with MoU-compliant device-end connectors.

1.4 IS THERE A NEED FOR FURTHER HARMONISATION MEASURES?

To the best of our knowledge, there is no official data on the total number of active mobile devices in the EU. However, according to our survey conducted during September 2019, to which we will return later in this report, the average EU household has approximately 5 mobile devices that require charging (excluding laptops), cf. Figure 11.[13] Given that there are approximately 200 million

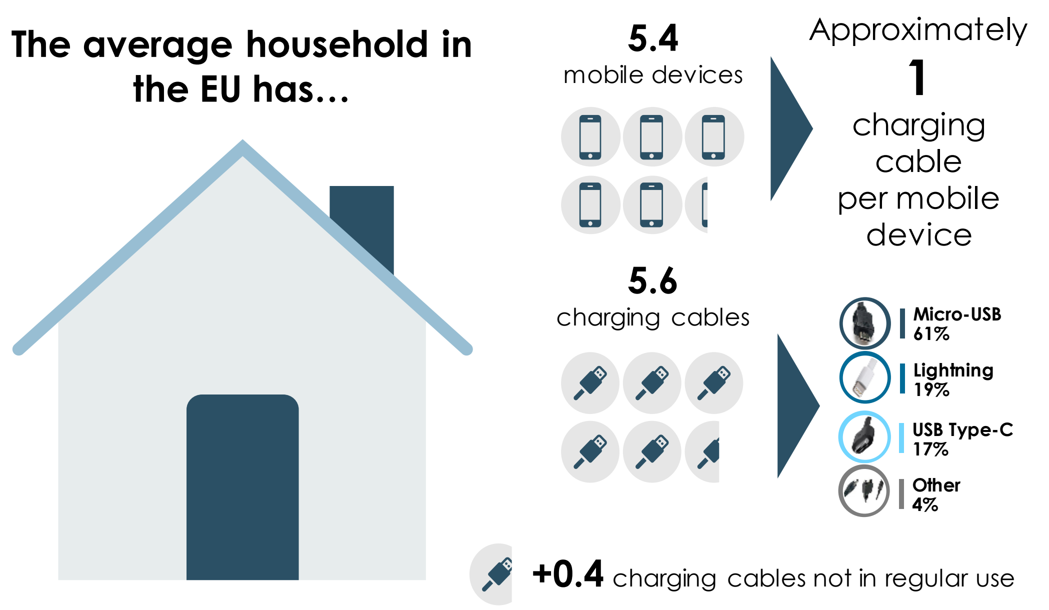
[12] The first letter of intent was signed by Apple, BlackBerry, Huawei, LGE, NEC, Nokia, Samsung and Sony, and the second letter of intent was signed by Apple, BlackBerry, Huawei, Samsung and Sony.

[13] Mobile phones, tablets, e-readers, cameras, GPS satellite navigators, speakers, smartwatches or other wearables and other mobile devices.

households in the EU,[14] this suggests that there are approximately 1 billion active mobile devices (excluding laptops) that require charging in the EU.

Furthermore, our survey shows that the average EU household has 1.04 charging cables (detachable or non-detachable) per mobile device. Additionally, the average EU household has 0.4 charging cables not in regular use (e.g. cables to old devices that are no longer used). Hence, our survey evidence suggests that there are approximately 1 billion charging cables in use in the EU, with a rough 60-20-20 split between USB Micro Type-B, Lightning and USB Type-C device-end connectors.

Figure 11
Number of mobile devices and types of charging cables in the average EU household, September 2019
Number of mobile devices and charging cables



Note: Mobile devices included in the survey are mobile phones, tablets, e-readers, cameras, GPS satellite navigators, speakers, smartwatches or other wearables and other mobile devices.
Source: Copenhagen Economics survey

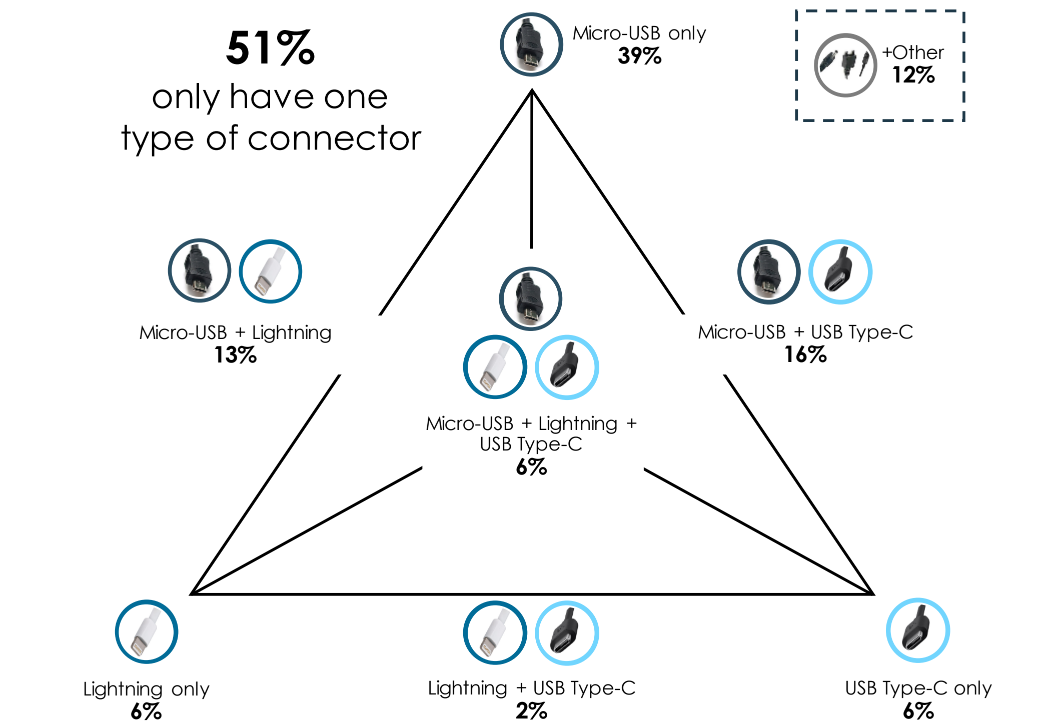
When looking into the different combinations of device-end connectors each household has, the most common setup is households with only USB Micro Type-B device-end connectors, cf. Figure 12. 39 per cent of households have only USB Micro Type-B connectors, while 6 per cent of the households have only Lightning connectors and another 6% have only USB Type-C connectors.

Regarding households that have multiple types of device-end connectors, the USB Micro Type-B and USB Type-C combination is the most common, with 16 per cent of households having that cable setup. At least some of these households are likely to be in a transition phase where their USB Micro Type-B cables and devices are being replaced by USB Type-C.

[14] Eurostat, Number of private households by household composition, number of children and age of youngest child (1 000)

13 per cent of households have at least one each of USB Micro Type-B and Lightning connector, while only 2 per cent of households have a Lightning and a USB Type-C connector, but not a USB-Micro Type B connector. Six per cent of the households have one each of the three major device-end connectors.

Figure 12
Detailed breakdown on the types of device-end connectors in EU households
Share of households



Note: The share of Other (12 per cent) represent the share of households that have at least one cable with another device-end connector than Micro-USB, Lightning or USB Type-C. If we instead discard those other cables, the shares of households with different cable setups become: Micro-USB 41%, Lightning 7%, USB Type-C 6%, Micro-USB+Lightning 15%, Micro-USB+USB Type-C 19%, Lightning+USB Type-C 2%, and Micro-USB+Lightning+USB Type-C 9%.
Source: Copenhagen Economics survey

Just over a half, 54 per cent, of EU households have only one type of device-end connector, and the Micro-USB is by far the most common type. The cable setup of those households is that they only have cables with either USB Micro Type-B, Lightning or USB Type-C device-end connectors. Out of those households, 3 per cent also have at least one cable with another type of device-end connector, cf. Table 1. Those households typically have at least one mobile device that is e.g. a camera, GPS satellite navigator, speaker, smartwatch or other wearable or other mobile devices (i.e. in addition to mobile phones and/or tablets).

Accordingly, 46 per cent of EU households have at least two of the three main types of device-end connectors. Out of those households, 9 per cent also have at least one cable with another device-end connector than any of the three main types - approximately 95 per cent of those households have at least one mobile device that is not a smartphone or a tablet.

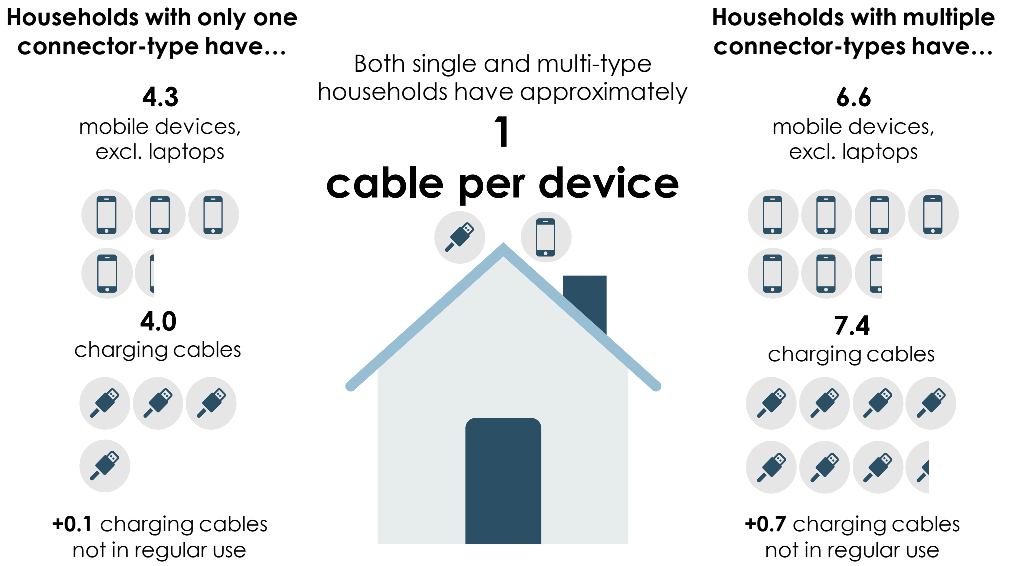
Table 1
Distribution of households with different types of device-end connectors in regular use, single-type and multi-type households

SINGLE-TYPE HOUSEHOLDS *Households with only one type of device-end connector*				
Only	USB Micro-B		**39%**	**= 51%**
	Lightning		+ **6%** +	
	USB Type-C		**6%**	
MULTI-TYPE HOUSEHOLDS *Households with at least two types of device-end connectors*				
Only	USB Micro-B / Lightning / USB Type-C	*+ Other*	**3%**	
			+	
Combination of:	USB Micro-B / Lightning / USB Type-C		**37%**	**= 49%**
			+	
Combination of:	USB Micro-B / Lightning / USB Type-C	*+ Other*	**9%**	
TOTAL			**100%**	**100%**

Source: Copenhagen Economics survey

Households that have two or more types of device-end connectors typically have more devices and more cables than households with only one type of device-end connector, cf. Figure 13.

Figure 13
Average number of devices and charging cables for EU households with one or multiple types of device-end connectors
Number of devices and charging cables



Note: Households with multiple connector types have at least two different types of device-end connectors. Mobile devices included in the survey are mobile phones, tablets, e-readers, cameras, GPS satellite navigators, speakers, smartwatches or other wearables and other mobile devices.
Source: Copenhagen Economics survey

Hence, households with multiple types of device-end connectors have 1.12 charging cables per device, while households with only one type of device-end connector have 0.93 charging cables per device, on average.

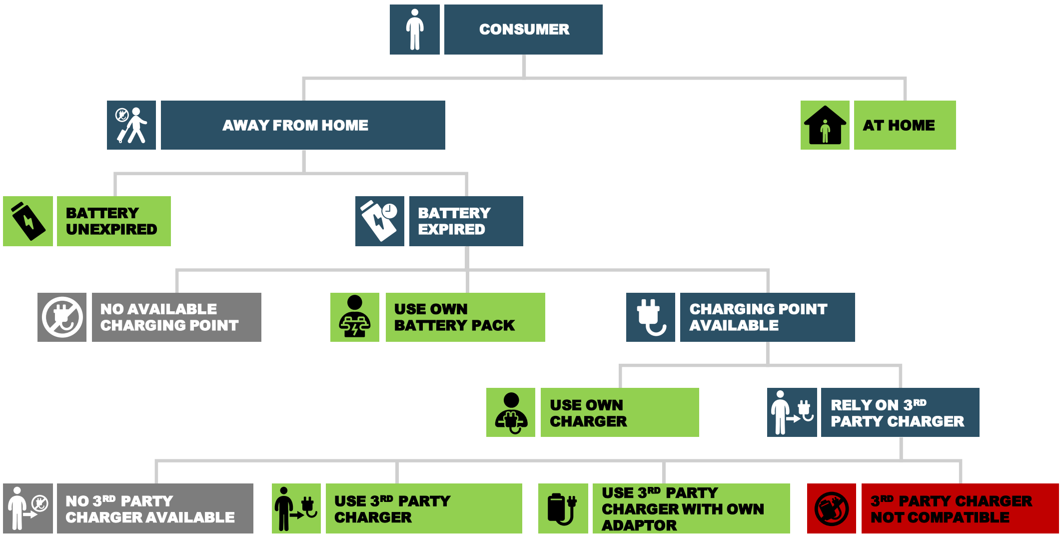
This suggests that there is a scope for reducing the total number of cables in the EU, insofar as the larger number of cables in the multiple-type households, albeit marginally, is driven by the fact that their devices require different types of device-end connectors. However, at closer inspection, there are actually not many situations in which a Common Charger would improve consumer convenience compared to the current situation, cf. Figure 14.

Specifically, a Common Charger would only improve consumer convenience in situations where there is a need to charge a device, but the only available charger is incompatible with that device. While such situations do occur, it is unlikely that they happen often. Furthermore, users who find such situations causing a major inconvenience are likely to carry a charger with them or make sure that devices are sufficiently charged before leaving the location where a cable and charging point is available.

Recent consumer evidence shows that only 0.4 per cent of EU consumers experience that it regularly causes a significant issue on at least numerous occasions per year that they are unable to charge their phone due to the available charger being incompatible with their own phone.[15]

In other words, not only is it rare that situations in which a Common Charger would improve consumer convenience occur, when they do it is likely that they do not cause a major inconvenience to consumers. The Common Charger initiative would of course not improve situations where one runs out of battery power without having a charging point available (e.g. a wall socket).

Figure 14
Situation in which a Common Charger would improve consumer convenience compared to the current situation



Note: The red box illustrates the situation in which a Common Charger would improve consumer convenience.
Source: Copenhagen Economics based on CRA, 2015, *Harmonising chargers for mobile telephones: Impact assessment of option to achieve the harmonisation of chargers for mobile phones*, page 24.

Even though the market is characterized by only a few types of device-end connectors, adaptors being available to enable any device to be connected with any charging cable, and the number of situations in which a Common Charger would actually improve consumer convenience, further efforts were undertaken during the past years to develop a new MoU on chargers for mobile phones. In March 2018, the industry organisation Digital Europe published an updated MoU.[16]

As with the MoU from 2009, the signatories[17] committed to gradually transition their smartphones to base their charging solutions on the most modern type of USB connector: USB Type-C, the specification for which was published in 2014. The MoU spells out that within three years from the

[15] Ipsos, 2019 (forthcoming), *IA Study on Common Chargers*. The calculation is based on 4% of respondents reporting that the "incompatible charger issue" has occurred either "almost every day" or "on numerous occasions" and that 9% of respondents reporting that it "caused a significant issue on a regular basis".
[16] DigitalEurope, 20 March 2018, *Memorandum of Understanding on the future common charging solution for smartphones*, available at: https://www.digitaleurope.org/resources/memorandum-of-understanding-on-the-future-common-charging-solution-for-smartphones/.
[17] Apple, Google, Lenovo, LG Electronics, Motorola Mobility, Samsung, Sony Mobile.

signing of the MoU, all new smartphone models released by the signatories would be chargeable with any of the following charging solutions:

- Cables with a USB Type-A block-end connector and a USB Type-C device-end connector
- Cables with a USB Type-C block-end connector and a USB Type-C device-end connector
- Cable assemblies with a USB Type-C connector on one end of the cable and a proprietary connector on the other end (hardwired or detachable)

However, the European Commission deemed the proposed MoU insufficient.

Figure 15
USB Type-C connector

Note: Unlike the USB Micro Type-B, the USB Type-C can be used both as a device-end as well as a charging block-end connector.
Source: https://www.colourbox.com/image/usb-cable-isolated-on-a-white-background-image-18951353

The Commission argues in the Inception Impact Assessment that the fact that the MoU would allow for different types of device-end connectors – USB Micro Type-B, USB Type-C and Lightning – while also not preventing other proprietary types to be launched in the future, means that it would not lead to full harmonisation of device-end connectors in the EU.

Furthermore, the Commission argues that while adaptors were permitted under the 2009 MoU, the introduction of the USB Type-C device-end connector to the market "*…does not appear to provide any technical advantages to justify maintaining of proprietary solutions*".[18]

Accordingly, the Commission is currently considering taking legislative action to completely eliminate device-end connector heterogeneity in the EU. It is currently being analyzed and assessed, through public and targeted consultations, whether or not the Commission shall move ahead with such a regulatory mandated Common Charger reform, as well as what form such a legal act should take (current options mentioned are a delegated act under the Radio Equipment Directive,[19] or a new legal act with Article 114 TFEU[20] as legal basis).

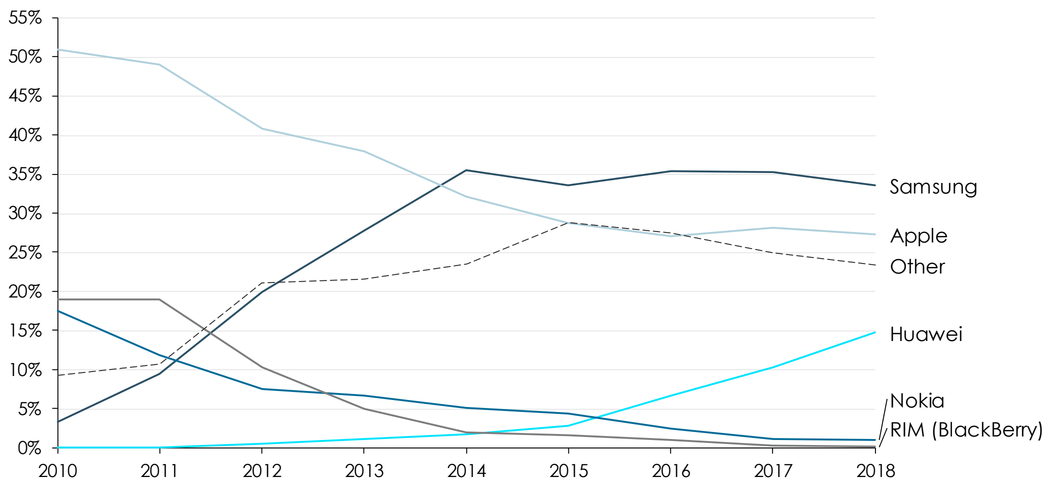
[18] European Commission, 2018, *Inception Impact Assessment: Common chargers for mobile telephones and other compatible devices*, Ref. Ares(2018)6473169 – 15/12/2018, p. 2.
[19] Directive 2014/53/EU, primarily article 3(3)a.
[20] The establishment and functioning of the Internal Market article.

1.5 THE BATTLE FOR CONSUMER PREFERENCES HAS LED TO BETTER CHARGING SOLUTIONS

A strong advantage of a competitive market economy with an ongoing battle to win the favour of consumers is that it forces companies to develop the products that meet consumer preferences.

Careful balance between legislation (on e.g. electrical safety), industry self-regulation (on device-end connector types) and market forces have created a dynamic environment where producers compete in a highly competitive market where consumers have a strong power to “vote with their feet”, cf. Figure 16. In a fast-moving market, producers face fierce competition to be at the cutting edge to attract consumers, illustrated by the drastic shifts in market shares for the big players of the industry.

Figure 16
The European market for mobile phones, market shares by producer, 2010-2018
Per cent



Note: The five producers that are highlighted are the only ones who have had at least 10 per cent of the European market during at least one of the years in the sample.
Source: Statcounter GlobalStats, available at: https://gs.statcounter.com/vendor-market-share/mobile/europe/#yearly-2010-2019.

Chargers have been improved by the market dynamics where consumer preferences have led producers to develop and innovate new products and features to gain an edge over the competitors. Today’s chargers are typically more energy-efficient, they can transfer power and data via the same cable, they are slimmer, and they have enabled devices to be more water and dust resistant.

As chargers have become slimmer, they require less material, and the newer types of chargers are so-called cold systems, in the sense that there is no power present in the charging pin when the cable is not plugged into a device (unlike the older types of chargers, which were “hot” systems).[21]

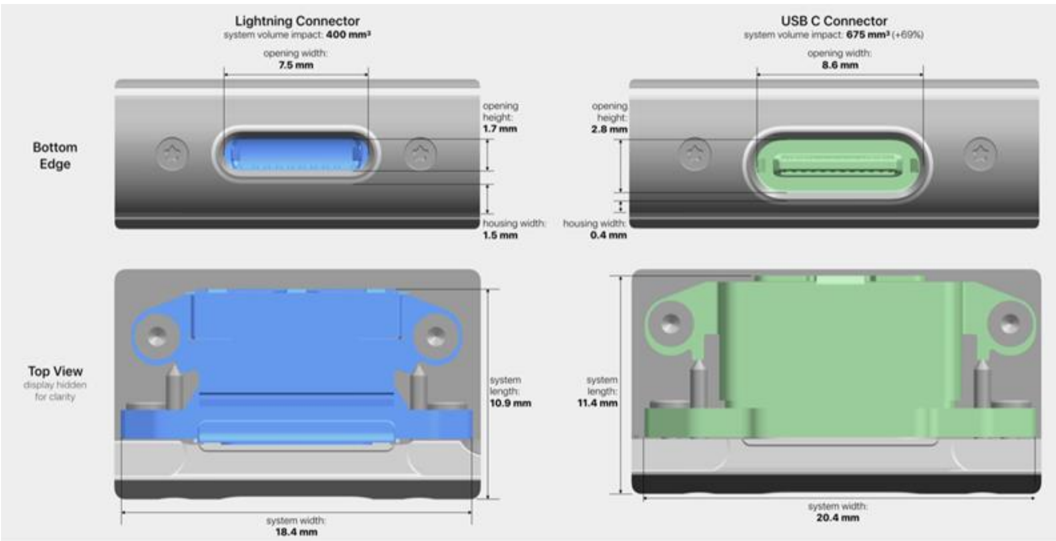
[21] Charles River Associates (CRA), 2015, *Harmonising chargers for mobile telephones - Impact assessment of options to achieve the harmonisation of chargers for mobile phones*, p. 17.

However, there is still room for improvement in chargers and charging cables, to reach faster levels of data and power transfer speed, new designs, and higher water and dust resistance.[22] In addition, there are of course possibilities that there are future innovations that are currently unknown to the market.

While consumers are likely to value convenience of being able to use the same cable across smartphone brands and device types, this is only one of many factors in their choice of producer. Consumer choice factors include, *inter alia*, functional aspects, design features, device size, camera, performance and touch screen functionality and quality.

The device-end connector impacts those factors that are important when consumers select which device producer to purchase from.[23] For example, not only is the USB Type-C connector larger than the Lightning connector on the outside, thus restricting how slim devices can be, it also takes up more space inside the device which impacts the space left for other components, such as the size of the battery. Overall, the USB Type-C solution takes up 69 per cent more space of a device than the Lightning solution. This has a significant impact on the design, slimness and internal hardware capacity of the devices.

Figure 17
External and internal size of the Lightning and the USB Type-C connector solutions



Note: The total system volume impacts at the top are derived from a calculation that considers the irregular shape of the coloured portions. That is, the volume figures are not a simple length x height x width figure based on the lengths, widths, and heights shown here. They consider the shape of the part in system, as some of the areas around the connectors can be used for system area. In addition, the actual area the connector occupies is dependent on where in the section it is placed, and so that is being accounted for here as well.
Source: Apple

[22] Cnet, 8 March 2018, *Apple has ideas for water-resistant Lightning connectors*, available at: https://www.cnet.com/news/apple-has-ideas-for-waterproof-lightning-connectors/.
[23] Risk & Policy Analysts (RPA), 2019, *Study on the Common Charger 2.0*.

1.6 THERE IS NO NEED FOR FURTHER HARMONISATION MEASURES

A natural selection process has led up to the current situation with only a **few types of device-end connectors available on the market**, but not one single. The market for mobile devices appears to be highly dynamic, as suggested by the drastic shifts in market shares for the producers of mobile phones.

Thus, there are **no signs of device-end connectors creating a lock-in effect** on consumers choice of producers. That a charging cable is typically included in the box when a new device is purchased makes it difficult to view cables as locking consumers into a single brand. If a consumer wants additional charging cables, their price is approximately between 3-5 per cent of the device price.

USB Type-C is an open standard,[24] and its uptake in almost every Android-operated device suggests that there are **no barriers to access the open standard for those producers that wish to use it**. Those producers who have chosen to maintain a proprietary device-end connector have been able to do so because consumers choose to buy their products even though, or equally possible, thanks to, they do not have the USB device-end connector. As the device-end connectors are different, and therefore impact the design and functionality of devices, they enable producers to cater to **consumers with different preferences**. That most consumers who own such devices have not chosen to purchase the available device-end adaptors is a further testament to that.

The same forces of consumer-driven market evolution have led to **homogeneity of the charging block-end connector** with detachable charging blocks and cables being commonplace. This has significantly improved consumer convenience, while this "infrastructure-side" standardisation does not interfere with the industrial design and innovation on the devices themselves.

Hence, there appears to be no market failure specific to device-end connectors that needs to be addressed by the legislator, given that great progress has been done already on charging blocks (and the infrastructure side) and the ability to use one device-end connector type across different device types (smartphones, tablets, e-readers, wearables, etc.). There are no signs that the market forces are inhibited by the current charger solutions.

[24] https://www.usb.org/documents.

CHAPTER 2

CHARGER INNOVATION CREATES LARGE CONSUMER VALUE

Smartphones and other mobile devices have become a large part of everyday life for most EU citizens. More and more economic and social activities take place or are organised on our mobile devices, and they are a necessary component in our modern lives.

This increased prominence of mobile devices has created a new essential activity in our lives – ensuring that they are charged. Most devices are powered by chargeable batteries and running out of battery power on a mobile device is a prominent modern nuisance that we try to avoid. As devices have become more advanced and capable of carrying out sophisticated tasks with minimum latency and disruption, tailored to each user's preferences, the power consumption of devices has increased.

While it may not be the first thing that comes to mind when one thinks about how mobile devices have transformed our lives, ensuring that they have sufficient battery power is an integral part of everyday life.

As shown in the previous chapter, the heterogeneity in the available types of chargers – or specifically, the types of device-end connectors – has been greatly reduced during the past ten years, and there are currently three types that are readily available on the global and the EU market: USB-Micro Type B, USB-C and Lightning. Adaptors are available that enable the usage of cables that do not directly fit the device.

The charging solution is one of many important features of a mobile device

The self-regulated reduction in the heterogeneity of device-end connector types happened in parallel with innovative efforts that made mobile devices – and therefore the need to keep them charged –more central in people's lives. Consumers demand more and better functionalities in their mobile devices and producers are in a continuous battle to woo consumers across all the different aspects and elements of using a mobile device, including, hardware, software, price, design, battery life, storage space, processing power, screen quality, camera features, audio and video capabilities, durability, security, and charging convenience (cf. Figure 18 for a charging dock for mobile devices).[25]

[25] See, *inter alia*, Statista, 2019, *What Smartphone Buyers Really Want*; or GlobalWebIndex, 2019, *Which Smartphone Features Really Matter to Consumers?*; or Engadget, 2017, *The most important smartphone features ranked*.

Figure 18
Example of Apple Lightning Dock

Note: The dock can be used for charging, synchronising with a computer, speakerphone calls, headphone plug-in.
Source: https://www.apple.com/shop/product/MGRM2AM/A/iphone-lightning-dock-white

Producers develop and innovate their product offerings and brand profiles to find the right balance across all the relevant features in order to tap into different consumer segments and their specific set of preferences. While all consumers need to charge their devices, each consumer is unique in terms of how and for what purposes they use their device and what features they consider important and valuable. Thus, one balancing act for producers is to develop and offer battery and charging solutions that are as convenient as possible for consumers, while enabling and allowing for other relevant features that consumers value.

Multiple but limited number of device-end connector standards allow producers to compete over device design and functionality
Competition in markets forces firms to produce higher quality products at a lower price. One important tool in firms' competition is innovation. New, innovative solutions help firms to gain a competitive advantage over its rivals, thereby attracting more consumers and increasing revenue.

Even if a Common Charger initiative may provide some benefits through network effects and increased interoperability, it will remove manufacturers' possibility to compete on charging solutions. Introducing a regulatory mandated Common Charger risks creating a market where producers rely on outdated technologies instead of exploring ways to innovate new solutions.[26] Producers and consumers would be forced to rely on the regulated standard, thus missing out on improvements in charging solutions that would have otherwise occurred. As recent mobile charger history shows us,

[26] Shurmer, M., and Lea, G., 1995, *Telecommunications standardization and intellectual property Rights: A fundamental Dilemma*

the process of upgrading and innovating a common solution (the USB standard) is slower compared to the launch and deployment of proprietary charging solutions.

Box 1 The Lightning connector struck consumers' chord

Apple launched the Lightning device-end connector in 2012. Compared to its predecessor, the 30-pin connector, the Lightning connector is smaller, thinner, flippable (i.e. it is orientation independent, meaning that it can be plugged in "upside-down"), has higher data wattage capability, offers faster data transfer speeds and is less fragile (both for the cable as well as the device it is connected to).[27]

For all the benefits of the Lightning connector compared to the 30-pin, there was, however, one downside – consumers had stocked up on products using the 30-pin connector, now incompatible with devices using the new connector.[28] While adaptors were offered, the connector change caused a transitional inconvenience for consumers.

Thus, introducing a new type or version of a product that is used in connection with other devices and accessories causes a transitional inconvenience for consumers. In addition, back in 2012 when the Lightning connector was launched, there were not as many Apple devices on the market that used the 30-pin connector that had to be replaced by the Lightning connector. The transitional inconvenience is thus likely to be greater today if all Lightning devices had to be replaced with a new connector type.

However, as long as the new type or version offers significant enough benefits, it can be motivated. In a market economy, it is the consumers that have the power to decide whether the benefits outweigh the costs. If the new type or version of a product is well-received, the producer enjoys higher sales, and if it is not, the producer faces decreased sales and its competitors will be in a relatively stronger position. Producers have the freedom to take the chance of introducing new technology on the market. If not, consumers risk losing out on improvements and innovation.

27 Macworld, 13 September 2012, *Lightning: the iPhone's new connector*, available at: https://www.macworld.com/article/1168555/what-apples-new-lightning-connector-means-for-you.html.

28 ANEC, 20 September 2012, *iPhone 5 – Consumers struck by Lightning*, available at: https://anec.eu/images/Publications/press-releases/ANEC-PR-2012-PRL-010rev.pdf.

Box 2 USB Type-C – the all-in-one cable

The USB Type-C specification was published in 2014 but it took until 2015 for the first devices to be shipped with the new connector (such as Apple's MacBook, Google's Chromebook Pixel and the Nokia N1 tablet)[29]. In 2016, it started to become readily available on smartphones – most new models using the Android operating system, such as Huawei and Samsung, use USB Type-C. In addition, it is possible to purchase cables with a USB Type-C block-end connector, also for cables with a Lightning device-end connector.

The USB Type-C cable and connector specification was developed by a specific work group with experts from firms such as Apple, Google, Hewlett-Packard, Intel, Lenovo, Microsoft and Samsung participated.[30]

As with the Lightning device-end connector, the USB Type-C is flippable, unlike previous USB connectors. However, that is not the only improvement of the USB Type-C compared to its predecessors – it is indeed intended to be the cable for everything.[31] The USB Type-C can conduct up to 100 watts of power, which is especially useful for laptops and other power-hungry devices.[32]

USB Type-C cables can also transfer data at a higher speed than any other cables, though the data transfer speed depends more on the underlying transport technology than the type of device-end connector. Lastly, the USB Type-C cables and connectors can support many different types of data protocols, such as HDMI and DisplayPort. Compared to the less capable USB Micro-B connector, the USB Type-C connector is larger.

It remains to be seen whether, and if so in what timeframe, the USB Type-C will become the only cable on the market.

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29 Intel Newsroom, 10 March 2015, *USB Type-C: Where it came from and where it's going*, available at: https://newsroom.intel.com/editorials/usb-type-c-history/#gs.i6v2ba.

30 https://www.docdroid.net/uf3z/typec.pdf#page=2. Apple contributed with 18 out of the total 79 experts in the work group.

31 Hackaday, 29 July 2019, *USB-C: One plug to connect them all, and in confusion bind them*, available at: https://hackaday.com/2019/07/29/usb-c-one-plug-to-connect-them-all-and-in-confusion-bind-them/.

32 Cnet, 26 October 2016, *USB Type-C and Thunderbolt 3: One port to connect them all*, available at: https://www.cnet.com/how-to/usb-type-c-thunderbolt-3-one-cable-to-connect-them-all/.

2.1 THE COMMON CHARGER INITIATIVE RISKS RESTRICTING THE FORCES THAT DRIVE INNOVATION AND CONSUMER WELFARE

The stated objective of the Common Charger initiative is to increase consumer convenience. The assumption is that consumers would find increased interoperability between chargers and devices convenient. However, mandating a single type of device-end connector through legislative means may lead to the unintended consequence of restricting producers from making valuable improvements to meet future consumer demand and preferences of the charging solutions for mobile devices.

The market for chargers has hitherto developed in absence of regulatory mandated requirements. Producers' innovations and consumers' preferences have dynamically brought about the current situation with near-full harmonisation of chargers and substantial increases in consumer value from innovation and improvements in charging solutions.

The Common Charger initiative can be understood as the EU deciding to adopt one single device-end connector standard. The Inception Impact Assessment (IIA) of the Common Charger initiative does indeed refer to "*The needs for standards and interoperable solutions*"[33] when motivating the basis for EU intervention with regards to the subsidiarity principle.

This would mean a departure from the current situation where there are three different types of standards that primarily are available in the market.[34]

In certain cases, adopting a standard can increase the efficiency and boost market innovation, as producers can spend fewer resources on the standardised features of a product and more resources on innovating and improving the non-standardised features of a product. As such, it is important to note that innovation and improvement of the product features that are standardised slow down or cease completely.

The long-standing efforts to harmonise and standardise certain products and product features across the EU has led to increased trade, production and welfare.[35] However, the benefits have been achieved thanks to the careful process whereby it is ensured that there is consensus of a clear added value of adopting a single standard that outweighs the restriction on innovation that a standard naturally entails.[36] In a European Commission guide it is argued that standards relieve "*…innovators of the need to make decisions on what are often quite trivial matters, allowing them to concentrate on the essential essence of their innovation*".[37]

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33 European Commission, 2018, *Inception Impact Assessment: Common chargers for mobile telephones and other compatible devices*, Ref. Ares(2018)6473169 – 15/12/2018, p. 2.

34 Though it should be noted that the tri-connector type market is, at least to some extent, an effect of the transitory period where the USB Micro Type-B is being replaced by the USB Type-C device-end connector. However, in a dynamic market where innovation and improvements are introduced, it is possible that there will always be a level of transition present in the market.

35 Hatto, P., 2010, *Standards and Standardization Handbook*, prepared for the European Commission.

36 Hatto, P., undated, *Standards and Standardisation – A practical guide for researchers*, prepared for the European Commission.

37 Ibid, p. 15.

However, this chapter will show that connectors used for charging on mobile devices are not trivial matters – in fact, they carry significant value for consumers. The Common Charger initiative aims at increasing consumer value thanks to increased convenience of charger interoperability. In doing so, it puts significant future consumer value at risk since it restricts the incentives on producers to innovate and improve a product feature that most EU citizens encounter and use on a daily basis.

Standardisation and innovation – striking the right balance for consumer welfare
Standards help to create a mutual understanding of products, processes and services in a market.[38] There can be many reasons to introduce standards, such as ensuring minimum quality and safety, increasing interoperability, optimising production methods and supply chains or cutting transaction costs in both business-to-business (B2B) as well as in business-to-consumer (B2C) transactions.

Standards commonly result from consensus-based agreements between different parties of the standardising community, e.g. manufacturers, suppliers, industry organisations and governmental authorities. Compliance with consensus-based standards are *not* mandatory but they are often recognised by a standardisation body that helps preparing and publishing the guidelines, rules and requirements.[39] Relevant standardisation bodies for ICT products include the International Electrotechnical Commission (IEC) and the designated European Standards Organizations: the European Committee for Standardisation (CEN), the European Committee for Electrotechnical Standardization (CENELEC)[40] and the European Telecommunications Standards Institute (ETSI).

Even though these organizations develop voluntary standards it is possible for the European Commission to request the European Standards Organizations to develop and adopt standards to support EU legislation under the so-called "New Approach".[41] These requests concern defining essential requirements relating to health, safety and environmental issues that products must meet in order to be lawfully placed on the EU market.

It is also possible for the Commission to adopt legislation that refers to a standard instead of specifying the relevant product characteristics in the legislative piece, thus making the standard mandatory while delegating the drafting and maintenance of the specific requirements to relevant industry experts.

The Inception Impact Assessment of the Common Charger initiative states that it is not decided what legal basis and form the initiative will take, if the Commission decides to move ahead with the initiative. It does, however, argue that e.g. the Radio Equipment Directive[42] empowers the Commission to "*…impose harmonised solutions"* of common chargers.[43]

Under what conditions can standards improve efficiency and be a force for innovation?
It is widely recognised that official, publicly available standards and standardisation of products, processes or services can have positive impacts on industries, the economy and broader society.

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38 https://www.cen.eu/work/products/ENs/Pages/default.aspx.
39 http://www.intracen.org/Part-3-Difference-between-standards-and-technical-regulations/
40 CENELEC works closely with the EU but it is not an EU institute.
41 https://www.cenelec.eu/aboutcenelec/whatwestandfor/supportlegislation/newapproachdirectives.html.
42 Directive 2014/53/EU.
43 European Commission, 2018, *Inception Impact Assessment: Common chargers for mobile telephones and other compatible devices*, Ref. Ares(2018)6473169 – 15/12/2018, p. 2.

Several studies performed in different countries have shown that the contribution from standards to GDP growth in several industrialised countries rate lies in the range of 10 to 30 per cent during the past decades.[44]

However, the positive impact crucially depends on the underlying market characteristics for the product that is standardised. Since a standard, by definition, prescribes a single way of doing something, it is important to ensure that it does not unduly restrict the innovative freedom in the market.

This is for example the case in markets where there are high *network effects*, meaning that each consumer enjoys a greater value of a certain technology or product if there are many other consumers that also use the same technology or product.[45] For example, mobile device producers have standardised on detachable charging cables with USB Type-A charging block-end connectors (cf. section 1.3), enabling network effects through increased interoperability between cables and charging blocks. Furthermore, it increases the value of producing built-in charging ports with USB Type-A receptacles on e.g. walls, tables or aircraft seats (cf. Figure 10).

However, if the market is large enough with a high enough number of users, the positive network effects may be achieved with multiple standards, as long as there are not too many standards in use at once. This is especially the case if there are adapters or technologies available that allow for interaction between the different standards. All of these factors help some markets efficiently sustain multiple technological specifications for functionalities serving similar aims.

If consumers have *homogenous preferences* of a certain product feature, a single standard is preferred over multiple standards.[46] It offers a large efficiency gain to a market, and value for consumers, if producers agree on a single way of doing something that users have the same preference for. Costs and prices can be lowered, thanks to economies of scale in production.

For example, the fact that producers of chargers for mobile phones have settled on detachable cables using USB Type-A charging block-end connectors is evidence to suggest that consumers have homogenous preferences for charging blocks. However, consumer preferences of mobile devices are everything but homogenous and the market is dynamic across producers (cf. Figure 16).

Since the charging block-end connector has no impact on the design of the device and the charging block-end does not necessarily have to be plugged in/out whenever a device is being/have been charged, consumer preferences for types of charging block-end connectors are likely to be homogenous. The device-end connector, on the other hand, does impact the design of the device and it is necessarily being plugged in/out whenever the device is being/have been charged, it is much more closely related to consumers' device preferences.

Hence, mobile device producers have self-standardised on the infrastructure side of the charging solution – the charging-block connection that enables network effects and where consumers have homogenous preferences – while maintaining the ability to offer differentiated solutions on the device side of the charging solution – the device-end connection.

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44 Blind (2013), "The impact of standardization and standards on innovation"
45 Blind, K., 2011, *An economic analysis of standards competition: The example of the ISO ODF and OOXML standards*
46 Ibid.

Regulation can be a barrier for innovation and future requirements and preferences
As noted in Box 2, Apple contributed in developing the USB Type-C, after the Lightning device-end connector was launched in 2012, and were able to bring insights and knowledge into the USB Type-C development process from their own experience of developing the Lightning connector.[47] The USB Type-C was developed by representatives of a number of electronics firms, and was published in 2014 and introduced on the market in 2015.

Hence, consumers were able to enjoy the new generation of flippable device-end connectors with improved power and data transfer capacities two years before the USB Implementing Forum was ready to publish the USB Type-C connector, and three years before the USB Type-C connector was launched on the market. The time lag before these innovations manifested in a USB standard could have been much greater for at least two reasons. First, it may well be the case that the launch of the Lightning connector helped speed up the efforts of developing the USB Type-C as Apple's competitors were stuck with non-flippable connectors. Second, Apple itself joined the USB working group developing USB Type-C—apparently more immediately focused on use in laptops rather than phones[48]—and its contributions helped make it possible for USB-IF to publish the standard less than one year later.[49]

A Common Charger may end up weakening the competitive dynamic in the market, as well as creating barriers that limit manufacturers' ability to innovate or meet future requirements or consumer preferences by restricting the design and capabilities of devices along some dimensions. For example, a Common Charger will set a limit for how thin a smartphone or another mobile device can be.

The potential limitations imposed by a regulatory mandated harmonisation of chargers are also recognised in the Commission's official evaluation of the impacts of the Memorandum of Understanding.[50] According to the report, rigid charger regulation for the future may impede the improvements needed to meet future requirements.

From a consumer value perspective, imposing a single way of doing something restricts competition and innovation, and is therefore reserved for matters that carry little value for consumers. The remainder of this chapter will show that innovation and improvements in device-end connectors carries great value for EU consumers.

2.2 SURVEY EVIDENCE: CONSUMER VALUE HAS INCREASED SIGNIFICANTLY THANKS TO PAST DEVICE-END CONNECTOR INNOVATION

Innovation in chargers and cables has been created in a market where the industry has developed and adopted standards to their devices in a highly competitive environment. Producers of mobile

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47 "*So we contributed to a new universal connectivity standard that combines the essential functions you need every day in one dynamic port. The amazing USB-C port….*" https://www.apple.com/au/shop/product/FF855X/A/refurbished-12-inch-macbook-11ghz-dual-core-intel-core-m-silver

48 Apple Newsroom, 9 March 2015, *Apple Unveils All-New MacBook*, available at: https://www.apple.com/newsroom/2015/03/09Apple-Unveils-All-New-MacBook/.

49 Apple's U.S. patent 9,537,263, "Connector receptacle having a shield," is an example of a patent issued from an application filed November 17, 2013, shortly before Apple joined the USB Type-C working group and began contributing concepts described in this patent and elsewhere.

50 Risk & Policy Analysts, 2014, *Study on the Impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*.

devices compete over a number of features and capabilities, where consumers have strong power to vote with their feet and abandon brands that do not offer new and interesting features and solutions.

To the best of our knowledge, it has previously not been assessed how consumers value past charger innovations. A challenge in assessing the value consumers assign to the modern types of device-end connectors is that consumers pay for the combined product offering of devices, charger, charging cable, headphones, etc, and not for the features of the chargers per se. Thus, the price difference between flagship models and predecessors is a good proxy for the value of all the new features combined, but one cannot be certain of how much of that value that can be attributed to features related to the device-end connector.

Our analysis, on the basis of a consumer survey, provides novel data on how consumers value the improvements in chargers and cables. Importantly, our analysis isolates the impact of charger improvements from other improvements in mobile devices that have been introduced to the market. Our survey covers five countries (Germany, France, Italy, Sweden and Poland) with a total of 500 respondents.

To estimate the impact of charger innovation, we compare the current actual situation (status quo scenario) with a counterfactual scenario where the newest device-end connectors were not introduced to the market. By focusing on the absence of past innovation, we create a proxy for the potential value of future innovation that a Common Charger reform risks delaying for or denying consumers.

The full survey questionnaire can be found in Appendix A. The questions relating to the value of past innovation were asked of only those respondents who have experience in using at least the Lightning device-end connector *or* the USB Type-C device-end connector. Consumers with no experience of using the modern device-end connectors cannot be readily expected to provide an estimate on the value.

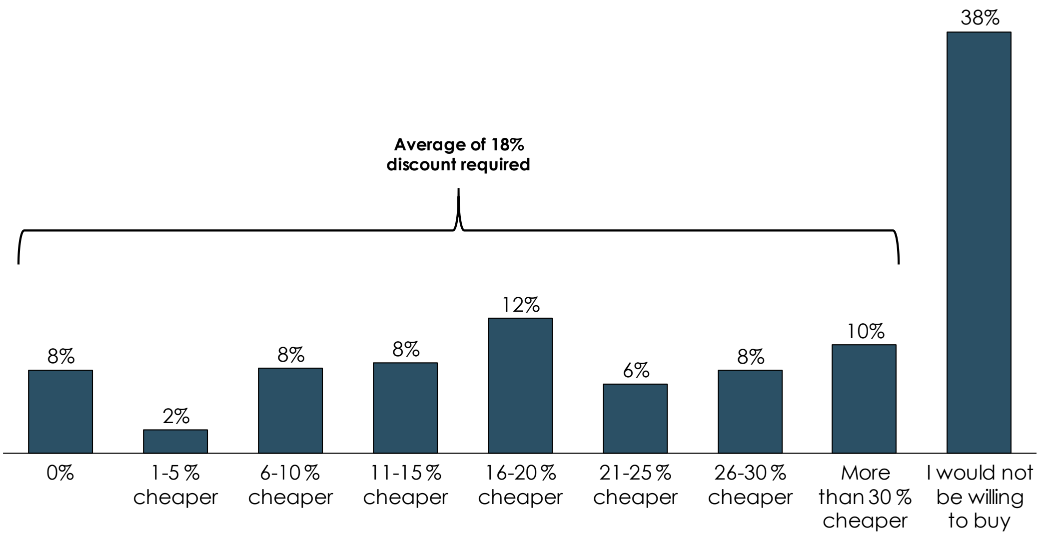
2.2.1 Consumer valuation of past device end connector innovation: overall EU-wide results

Firstly, consumers place a large value on having the most modern types of device-end connectors for their mobile devices. When asked for what discount consumers would require for them to choose to purchase a mobile device that uses an older type of device-end connector, instead of their current mobile device that uses a modern type of device-end connector (either USB Type-C or Lightning), 92 per cent would require at least some discount, cf. Figure 19.

Among the respondents who would accept a device using an old type of device-end connector as long as that device is discounted, the average required discount is 18 per cent. In other words, consumers would deem a device that uses an old type-of device-end connector as 18 per cent less valuable, than a device that uses a modern type of device-end connector (and only based on the features that are affected by the device-end connector and charging solution).

Interestingly, 38 per cent of the respondents would not be willing to buy a device if it uses an older type of device-end connector, *regardless of discount*.

Figure 19
Discount required for a mobile device with old type of device-end connector
Per cent

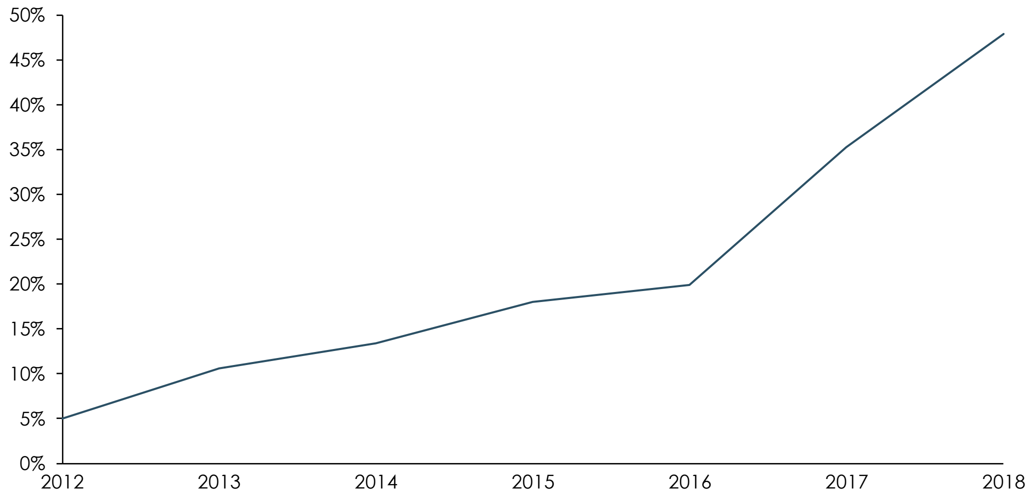


Note: Question to respondents: Imagine that you were offered to buy a device which is exactly as the one you currently have but with one difference: and old type of device plug and thus the set of features in the above table (such as lower speed, need for multiple data or energy cables, etc). How much cheaper would the device with the old type of device plug have to be for you to choose to buy it, instead of your current mobile device? In other words, what discount would make it equivalent to your current mobile device?

Source: Copenhagen Economics survey

In 2012, when the Lightning connector was launched, 5 per cent of the stock of smartphones in the EU used one of the modern types of device-end connectors (i.e. the Lightning connector). The share grew steadily and reached almost 20 per cent in 2016, as essentially all iPhones on the market had the modern device-end connector and those Android users who were early in purchasing phones using the USB Type-C connector that was launched the previous year. During the years that followed, as the USB Type-C became more commonplace in the market, the share of the stock of smartphones that use a state-of-the-art device-end connector (Lightning or USB Type-C) had reached almost 50 per cent in 2018, cf. Figure 20.

Figure 20
Adoption path: Smartphones using Lightning or USB Type-C in the EU
Percentage share of total stock of smartphones



Note: The Lightning device-end connector was launched in 2012 and in a few years almost every iPhone used the Lightning connector. The USB Type-C was launched on the market in 2015 and has quickly gained popularity among Android smartphones, and there appears to be a transition process where the USB Micro B is being phased out.
Source: Copenhagen Economics based on market and sales data from IDC.

By using data on total sales of smartphones on the EU market, the development of the share of the total stock of smartphones using either USB Type-C or Lightning (as in Figure 20), the average price of smartphones for each year 2012 to 2018[51], and the stated consumer value (discount required, as in Figure 19), we are able to calculate the total consumer welfare that is attributable to device-end connector innovation during 2012-2018.

The total consumer value that the state-of-the art types of device-end connectors have generated during 2012-2018 is **14 billion euro**, based on the most conservative estimate, cf. Table 2.

[51] Based on Statista, Smartphone average price forecast in in 2019, by region https://www.statista.com/statistics/283334/average-smartphone-price-by-region/, accessed on 19 November 2019.

Table 2
Past consumer value of Lightning and USB Type-C, 2012-2018

Variable	Formula	Value	Label	Source
Number of smartphones sold in the EU (excl. UK) 2012-2018 (7 years) with Lightning or USB Type-C device-end connectors		212 mn.	A	IDC data
Average price of a smartphone in the EU		€ 373	B	Statista[52]
Value of smartphones sold in the EU (excl. UK) 2012-2018 (7 years) with Lightning or USB Type-C device-end connectors	A*B	€ 79.0 bn.	C	CE calculation
EU consumer value attributable to modern device-end connector as share of device price		18%	D	CE survey (Figure 19)
Past consumer value of device-end connector innovation 2012-2018 (7 years)	**C*D**	**€ 13.9 bn.**	**E**	**CE calculation**

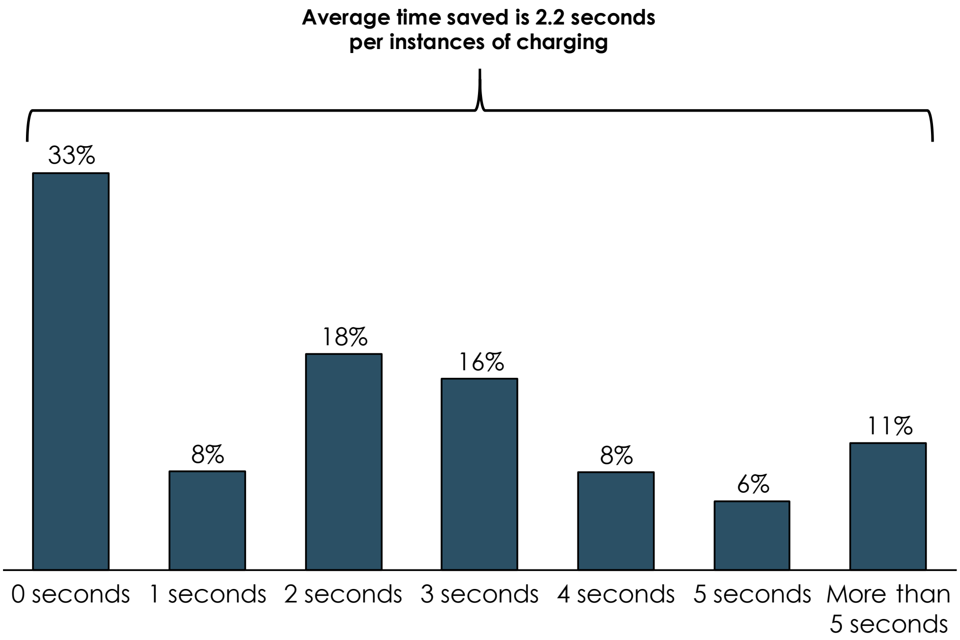
Source: Copenhagen Economics

2.2.2 Survey evidence: Flippable device-end connectors help consumers save time and increase convenience

We also take a deep-dive on the convenience of using modern device-end connectors. For one thing, both the Lightning and the USB Type-C connectors are flippable, such that they can plug in when turned upside down, unlike e.g. the USB Micro Type-B or the USB Type-A connectors. This analysis helps to test the reasons why consumers place value on the innovation delivered via device-end connectors.

[52] Price data is based on https://www.statista.com/statistics/283334/average-smartphone-price-by-region/, accessed on 19 November 2019.

Figure 21
Time saved when plugging in and out with modern types of device-end connectors
Per cent of respondents



Note: Question to respondents: Now compare the movement and process of plugging in a mobile device that has a USB-C or a Lightning device plug vs an alternative type of plug that has a different size and may not be a symmetric shape of plug (i.e. not reversible: only one side works). How much faster is it for you to plug in a USB-C or a Lightning device plug compared to other types of device plugs that you have used?
Source: Copenhagen Economics survey

67 per cent of respondents report that they save time by using the modern, flippable device-end connectors. On average, consumers report that they save 2.2 seconds per charging instance – i.e. when plugging in the cable into the device – with the modern, flippable device-end connectors, compared to older, non-flippable connectors.

By using the median income per hour in the EU, €8.3, to estimate the value of an individual's time,[53] we obtain a monetary value of the time consumers save when plugging in their devices for charging, thanks to the modern, flippable device-end connectors. Overall, the flippable device-end connectors generated time savings equivalent to **261 million euro** during 2018. This should be seen as a subset on the consumer value reported in Table 2, as the convenience of plugging in the modern device-end connectors is incorporated in the overall valuation of the modern types of device-end connectors.

[53] Eurostat, Mean and median income by age and sex – EU-SILC and ECHP surveys.

Figure 22
Valuation of the time saved thanks to flippable device-end connectors

There were **roughly 120 million smartphones in the EU in 2018** with either USB Type-C or Lightning connectors

Assuming one instance of charging a day, **USB Type-C and Lightning connectors saved around 26 million hours on EU-level in 2018.**

With a time valuation equal to the median income of EU28 (€8.3 per hour), **USB Type-C and Lightning connectors generated €261 million in consumer welfare on EU-level in 2018**

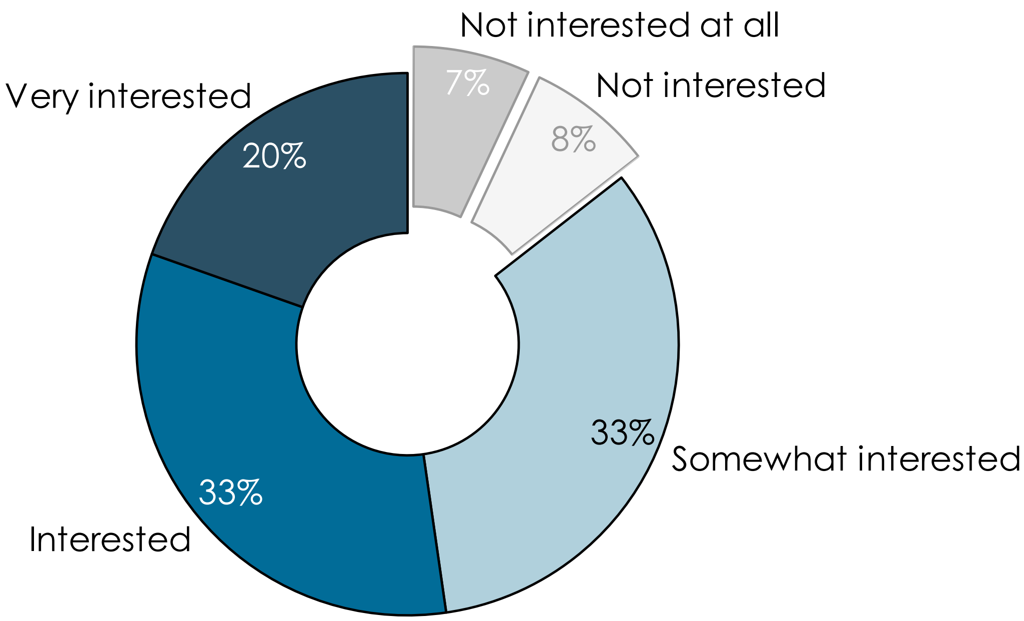
Note: The total value of the time saved is the product of the total number of hours saved and the median earnings in the EU28.
Source: Copenhagen Economics and Eurostat, Mean and median income by age and sex – EU-SILC and ECHP suveys.

2.3 IMPACT OF REGULATION ON FUTURE INNOVATION IN CONNECTOR TYPE SOLUTIONS: SIGNIFICANT CONSUMER VALUE AT STAKE

By using the evidence on the required discount for a device with an old type of device-end connector – the indicator of the value that consumers assign to the innovation and improvements in device-end connectors to date – we are able to calculate the prospective value that is at stake if the Common Charger initiative is adopted. Adopting a single type of device-end connector in the EU would strip producers of the chance to improve the product offering to consumers by innovating new and improved charging solutions. As device-end connectors carry significant value for consumers, they are anything but a trivial matter, and the producer who can come up with new, innovative charging solutions is likely to be rewarded by the consumers. Without this incentive, producers are much less likely to pursue efforts to come up with such solutions.

While it is notoriously difficult as a consumer to foresee the potential for future innovation – Henry Ford is believed to have said that if he had asked people what they wanted they would have said “faster horses” – it is clear that consumers are hungry for more charging innovation. 87 per cent of respondents state that they are at least somewhat interested in further innovation and improvements in the charging experience, while more than half are interested or very interested in it, cf. Figure 23.

Figure 23
Consumer interest in further charging innovation and improvements
Per cent of respondents indicating different levels of interest



Note: Question to respondents: Consider your current enjoyment and convenience of using mobile devices. How interested are you in more innovation and improvements in your charging experience of mobile devices in the future?
Source: Copenhagen Economics

It is of course possible that the Common Charger initiative allows for adaptation or improvements in the Common Charger – the Inception Impact Assessment does indeed state that the Common Charger should not hamper technological evolution. However, as the recent charger history has shown us in Box 1 and Box 2, the proprietary Lightning connector was developed and launched for consumers to enjoy three years before the common, open standard, all-compatible USB Type-C was launched. Given that Apple's engineers contributed to the development of the USB Type-C based on innovations made for Lightning, it is possible that the USB Type-C cable and connector would still not exist if it were not for Apple's ability to launch and sell a proprietary device-end connector.[54]

In the following, we estimate the loss of consumer value from a three-year delay in innovation, cf. Table 3.

[54] Gruber, John, host, 12 March 2015, *A Tube of Lubricant for Your Life*, The Talk Show, Daring Fireball. Available at: https://daringfireball.net/thetalkshow/2015/03/12/ep-113, at 54:02-55:47.

Table 3
Variables and results for calculating the loss of consumer welfare from a 3-year delay in the introduction of a charging solution innovation

Variable	Formula	Value	Label	Source
Sales of smartphones in the EU (excl. UK) during a 7-year period		994 mn.	A	IDC data and CE forecast (constant sales as in 2018)
Sales of smartphones in the EU (excl. UK) having the new innovation		263 mn.	B	CE calculation based on historical adoption path (Figure 20)
Average price of a smartphone in the EU in 2019		€ 373	C	Statista[55]
Value of smartphones sold in the EU (excl. UK) having the new innovation	B*C	€ 98.1 bn.	D	CE calculation
EU consumer value attributable to the new innovation as share of device price		18%	E	CE survey (Figure 19)
Consumer value of the new innovation, not discounted	D*E	€ 17.7 bn.	F	CE calculation
Social discount rate		4%	G	EU Better Regulation Toolbox 61
Without delay in innovation				
Net Present Value (NPV) of consumer value of the new innovation	See note	€ 13.2 bn.	H	CE calculation
With 3-year delay in innovation				
Net Present Value (NPV) of consumer value of the new innovation	See note	€ 11.7 bn.	I	CE calculation
NPV loss of consumer value due to a 3-year delay in innovation	**I-H**	**- € 1.5 bn.**	**J**	**CE calculation**

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate. See Appendix B for sensitivity tests regarding the above results.
Source: Copenhagen Economics

55 Price data is based on https://www.statista.com/statistics/283334/average-smartphone-price-by-region/, accessed on 19 November 2019.

First of all, as in any policy evaluation, we need a consistent future time interval over which to evaluate future impacts of a pending decision (i.e. the possible Common charger regulation). We set this interval at seven years for all areas of forward-looking evaluation (innovation impacts, as well as environmental impacts in section 4.5). The interval of seven years is chosen to match the length of time over which past evidence is available as to prior trends in diffusion of new connector technologies, i.e. the time between the launch of the Lightning connector (2012) until the last full year with available data (2018). We do so since we use evidence from how consumers evaluate the consumer welfare from the past wave of connector innovation in order to estimate impacts of regulation on the consumer welfare associated with a potential future wave of innovation in connector types.

Hence, we calculate the future consumer value that is at risk if a Common Charger is imposed on the EU market by comparing the Net Present Value (NPV) in 2019 of a three-year delay in the market introduction of an innovative charging solution.

Based on historical sales data[56] of mobile devices in the EU (excluding the UK), we project future EU sales of mobile devices. Over the period 2022-2028, there will be an estimated 994 million mobile devices sold in the EU.

By using the historical adoption path of the modern device-end type of connectors (cf. Figure 20), 263 million of those sold devices will have the new innovative feature.

We apply an average price of €373 for a mobile device, based on the average price of smartphones in Europe.[57] The price for a mobile device is discounted by 4 per cent[58] each future year to obtain the Net Present Value of a mobile device in 2019.

Lastly, we apply the 18 per cent increase in consumer value from charger innovation (cf. Figure 19), meaning that in a scenario where the Common Charger is not introduced and therefore innovation is not delayed, the charger innovation leads to an increase in EU consumer welfare of 13.2 billion euro (NPV).

If, instead, the regulatory mandated Common Charger is introduced, leading to a delay in the market-introduction of the innovation by three years (i.e. in the same way as it did in the past when Lightning launched three years earlier than USB Type-C), EU consumers would lose consumer welfare of **1.5 billion euro (NPV)**.

56 Based on market data from IDC.
57 https://www.statista.com/statistics/283334/average-smartphone-price-by-region/,
58 European Commission, Better Regulation Toolbox 61, https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-61_en_0.pdf.

CHAPTER 3

A FORCED COMMON CHARGER FOR THE EU WILL SEPARATE THE EU SINGLE MARKET FROM THE GLOBAL MARKET

3.1 A GLOBAL MARKET FOR CHARGERS

The USB and the Lightning standards are ones used on the global market for charging cables for mobile devices. IDC data on devices sold during the past five years suggests that the market share of the different cable types in the world is approximately 90 per cent USB and 10 per cent Lightning.

The corresponding shares in the EU is approximately 80 per cent USB and 20 per cent Lightning – our survey results reveal that the USB-Micro Type B is still the most common device-end connector in the EU, at 60 per cent – although there are significant differences among countries. In e.g. Sweden and Denmark, Lightning accounts for approximately 40 per cent of the market, while in e.g. Poland and Greece, it accounts for approximately 10 per cent.

Most devices, charging blocks and cables are produced in Asia – around 70 per cent of global smart phone exports are exported from China, Hong Kong and Vietnam.[59] This corresponds to the note in the Inception Impact Assessment, which states that a Common Charger reform would have minor impacts on EU competitiveness, seen from the production-side perspective. However, it should be noted that EU producers and designers of devices and accessories that are compatible with the Lightning connector may be negatively impacted if the EU Common Charger is selected to be e.g. the USB Type-C.

3.2 A RISK THAT EU CONSUMERS ARE MADE WORSE OFF BEYOND DELAYED INNOVATION

However, the risks would rather appear on the consumer-side. As we have already discussed and showed in the previous chapter, consumers assign great value to charger improvements and innovation and there is a risk that a regulatory mandated Common Charger will restrict or delay future innovation.

As such, the Common Charger would mean that consumers get a small (at best) short-term gain through increased network effects, for a large medium-to-long-term cost in terms of delayed or prohibited innovation.

A regulatory mandated Common Charger in the EU would also lead to some short-term costs to consumer convenience. As the global market is currently governed by the few industrial standards but no regional or national legislation restricting the design and features of device-end connectors, consumers benefit from large-scale production and global interoperability of mobile devices and chargers (the main restriction is rather the difference in AC power plug standards).

An EU Common Charger reform would add a regulatory barrier to the global market.

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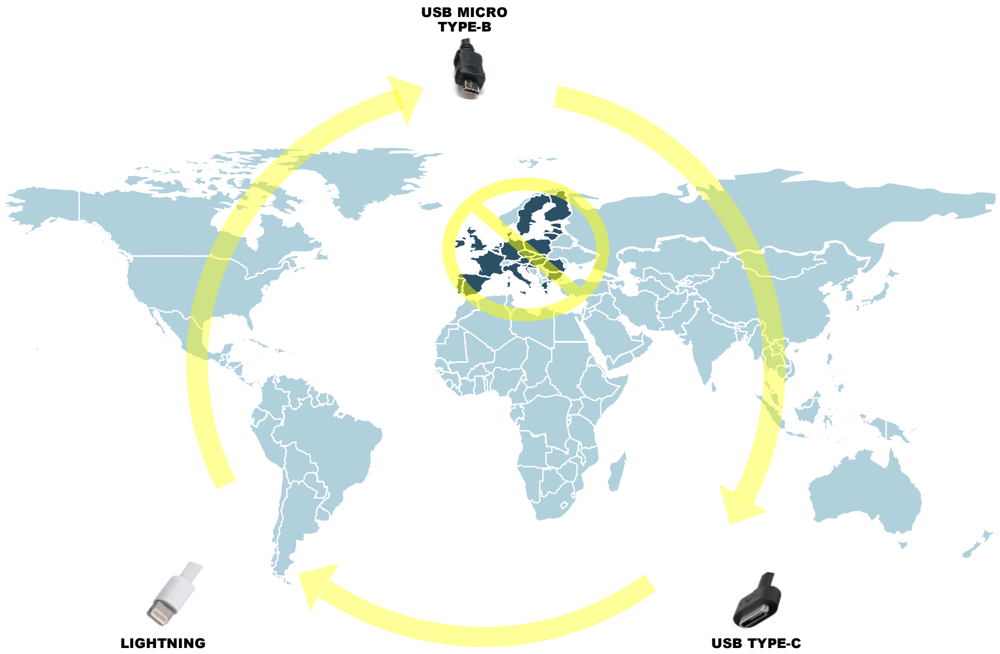
59 World's Top Exports, 22 September 2019, *Cellphone Exports by Country*, available at: http://www.worldstopexports.com/cellphone-exports-by-country/.

This could imply that:

- EU consumers would be paying a higher price for mobile devices and/or chargers since some producers would have to maintain separate production lines – one for the EU market, one for the non-EU market.
- Consumer convenience decreases, since an EU consumer that is outside the EU and needs to purchase a replacement charger for their device purchased in the EU, may find the required charger less readily available
- Consumer convenience may also decrease since a device purchased outside the EU cannot be charged with the producer's charger purchased in the EU, if the charging cable is damaged or lost and the consumer needs to purchase a replacement cable.
- EU consumers having to wait longer (or miss out) for new releases than non-EU consumers since the technology must be adapted to fit the EU Common Charger standard.

Figure 24
The world market for chargers with an EU Common Charger



Note: With the EU Common Charger, the EU single market is separated from the global market.
Source: Copenhagen Economics

Even if the market for chargers is characterised by a handful of device-end connector types, unilateral regulatory action to introduce a single EU Common Charger risks creating a non-tariff barrier to trade and thus lead to a "fortress Europe" effect that could unduly limit or delay the extent of supply and choice available to EU consumers.

The EU has a long history of successful harmonisation policies, often aimed at coordinating standard setting processes diverging along EU member states lines. These efforts, e.g. common EU product legislation, have delivered benefits to firms, consumers, and/or the environment by strengthening the functioning of the single market. In doing so, they have also bestowed economies of scale benefits upon suppliers compliant with EU standards (think for instance of the mobile phone ecosystem coalesced around the EU CEPT/ETSI GSM standards).

However, when it comes to device-end connectors, it does not seem that the specific outcome in a Common Charger regulation forcing a single connector type would bring significant benefits to the market.

Given that market mechanisms have already induced a large share of devices to converge on the USB device-end connector types (Micro B, now migrating to Type-C), plus the fact that there is near-complete convergence on USB Type-A and USB Type-C connector types on the charging block end, additional scale benefits associated with this type of regulation seem unclear.

In addition, unilateral EU action may set off other countries or regions of the world adopting a different Common Charger standard based on existing or future emerging standards (incl. wireless charging solutions), which may contribute to fragmenting further the global market with a compounded harm for consumers across the globe.

3.3 NO FRAGMENTATION IN THE EU SINGLE MARKET TO ADDRESS

While the Inception Impact Assessment mentions that the EU Single Market is fragmented, it is not clear how the type of fragmentation that it refers to constitutes a barrier to the free movement of the EU. Products (devices, chargers, charging cables) that are lawfully marketed in one EU member state can freely be purchased in any other member state. Furthermore, there are no regulatory or practical barriers that restrict this free flow of goods (apart from the different AC power plug standards in the EU, but the Common Charger initiative does not address that).

Normally, EU-wide standardisation or harmonisation removes barriers by reducing the number of regulatory requirements across the EU from 28 to one – in the case of device-end connectors, it would rather increase the number of regulatory requirements from zero to one. Apart from the significant risk it may pose to consumer value in terms of missed or delayed product innovation and improvements, it seems unclear what, if any, benefits an EU Common Charger will bring for EU consumer convenience.

As we will see in the next chapter, the environmental benefits also appear to be small.

CHAPTER 4

THE COMMON CHARGER WOULD YIELD, AT MOST, ONLY LIMITED ENVIRONMENTAL BENEFITS

In addition to improved consumer convenience, another stated objective of the Common Charger initiative is to lead to an environmental benefit through a reduction of electronic waste. This would be achieved, per the Commission, by a reduced need for consumers to purchase different types of chargers for different types of devices, and an increased ability to reuse old chargers.[60]

Indeed, the market-driven decrease in charger heterogeneity from a situation with more than 30 types of chargers in 2009, down to the current three types of chargers,[61] has led to a reduction in material use for charger production of around 1 to 4 per cent, according to the European Commission's official assessment.[62] The waste reduction was primarily driven by a decrease in sales of separately purchased chargers (so-called standalone chargers).

4.1 WOULD A FURTHER DECREASE FROM 3 TO 1 CONNECTOR TYPES GIVE MAJOR FURTHER ENVIRONMENTAL SAVINGS?

Although the achieved waste reduction is notable, it is a priori intuitively unlikely that a further reduction in charger heterogeneity – i.e. going the last mile and reducing the number of chargers from three to one after the past move from 30 to three – will lead to any significant waste reduction. After all, starting from 30 types of chargers and coming down to three means that charger heterogeneity has essentially already been eliminated, and the associated waste reduction essentially fully realised.

However, a priori intuitions benefit from a specific empirical test – which is what our survey-based analysis delivers, measuring the extent to which shifting to a situation where a single charger type is in place would affect consumer demand / behaviour and thus benefit the environment.

Furthermore, the environmental impact of chargers is not limited to the number of chargers sold. In fact, much has been achieved over the past years to reduce the carbon footprint of chargers.

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60 European Commission, 2018, *Inception Impact Assessment – Common chargers for mobile telephones and other compatible devices*, Ref. Ares(2018)6473169.

61 Essentially all mobile devices currently sold and in use are connected to the charger via either a USB Micro Type-B, a USB Type-C, or a Lightning device-end connector.

62 Risk & Policy Analysts (RPA), 2014, *Study on the impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*.

A prime example is the voluntary efforts of the industry to produce and sell cables that are detachable from the charging block, using a USB Type-A connector for the charging block-end side of the cable. That way, a charging block can be used for all types of cables, regardless of the type of device-end connector the cable has. This is especially helpful since the carbon footprint of producing a charging block is much larger than that of producing a charging cable (charging blocks use more material and are approximately 50-100 per cent heavier than cables)[63] [64].

Furthermore, a detachable cable is less prone to breaking as it can eject from the charging block (e.g. if a person trips over the cable). When, however, a detachable cable does break, an additional silver lining is that cost and environmental impact is contained, since a consumer only has to shift to a new cable and there is not an automatic demand for a new charging block.

In terms of consumer convenience, the transition to detachable cables has also reduced the need to carry around the relatively heavier and bulkier charging block, since the charging cable can be plugged into any charging block or any other power source with a USB Type-A socket. Furthermore, charging blocks have become slimmer and lighter (for each unit of power or data they can transfer), reducing the material use to produce each unit and the emissions from transportation.

Thus, in theory a legislative pursuit of reducing the number of chargers further can logically lead to some *additional* reduction in the environmental impact of chargers – above and beyond what the industry trajectory is already delivering. However, the genuine socio-economic and policy question is whether a significant additional reduction would be achieved, given the factors considered above.

Therefore, our empirical research via a European survey of consumers is designed to shed light also on this precise question. It does so by verifying the extent to which an exogeneous shock (such as regulation leading not just some but all households to use mobile devices a single connector type) would change consumer demand, habits and preferences for the number of cables/chargers that each household would then simultaneously keep in regular use.

4.2 PREVIOUS RESEARCH ON THE ENVIRONMENTAL IMPACT OF REDUCING MULTIPLE CHARGER TYPES FOCUSED ON THE SUPPLY SIDE

The comprehensive environmental impact of a Common Charger scenario has last been evaluated in a report prepared for the EU,[65] as well as in further studies,[66] both arriving at similar results: limited environmental benefits of past and further reductions in device-end connector heterogeneity.

As stated in previous chapters of this report, a Memorandum of Understanding (MoU) had already in 2009 committed 14 major manufacturers[67] (10 initially + 4 shortly after) to harmonise chargers

[63] Risk & Policy Analysts (RPA), 2014, *Study on the impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options,* p. 63.

[64] Risk & Policy Analysts (RPA), 2014, *Study on the impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*, p. 65.

[65] Risk & Policy Analysts (RPA), 2014, *Study on the impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*.

[66] Charles River Associates (CRA), 2015, *Harmonising chargers for mobile telephones – Impact assessment of options to achieve the harmonisation of chargers for mobile phones*.

[67] Motorola, LGE, Samsung, RIM, Nokia, SonyEricsson, NEC, Apple, Qualcomm and Texas Instruments were the original signatories, and Emblaze Mobile, Huawei, TCT Mobile and Atmel signed shortly after.

for mobile devices. Specifically, the mandate was based on all manufacturers enabling their devices to be charged with cables with a USB-micro device-end connector. Letters of Intent were subsequently signed in 2013 and 2014 to extend the commitments beyond the MoU's original expiration date in 2012.

The MoU reduced the number of different types of chargers on the market from more than 30 to only a couple, within a short period of time.[68] Furthermore, 99 per cent of all data-enabled mobile phones sold in 2013 complied with the commitments of the MoU,[69] since those manufacturers that produce devices with other than a micro-USB port offered (and still offer) adapters to consumers so that they can be charged with a micro-USB cable.[70]

While reduction in the heterogeneity in absolute number of device-end connector types has been very large, the corresponding reduction raw materials has been estimated as 400 to 1,330 tonnes during 2011-2013, which constituted 1.3-4.3 per cent of the total material used for chargers sold in the EU over the period. This was primarily driven by a reduction in sales of standalone chargers (i.e. separately sold chargers), which represents only a small fraction of the total number of chargers on the market.[71]

Therefore, previous research argues that significant environmental benefits will primarily be achieved through a reduced practice of providing chargers in the box when a device is being purchased. This is referred to as decoupling, as the charger is no longer included in the purchase of a new device.

Thus, a key research question to be clarified is whether and how much a Common Charger (which does not per se imply decoupling) would bring environmental benefits on its own.

4.3 A DEMAND-FOCUSED METHOD TO ANALYSE THE SPECIFIC IMPACT OF REGULATION ON ENVIRONMENT

Previous research on the impact of a Common Charger has focused on the supply-side effects, i.e. how producer habits would change – increased practice of not providing a charger in-the-box with every new device purchase – based on the increased interoperability of charging cables. It is found that the additional environmental benefit, beyond what the producers are already delivering through market-based measures, is limited, at best.

In order to add further insights and knowledge on how a Common Charger may impact the environment, we complement the existing research by looking at the impacts from a demand-side perspective. Thus, we put the consumers – their preferences and behaviour – at the centre of the economic and policy evaluation of how a Common Charger reform may impact the EU.

68 European Commission, 2018, *Common chargers for mobile telephones and other compatible devices*, Inception Impact Assessment.

69 Risk & Policy Analysts (RPA), 2014, *Study on the impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*.

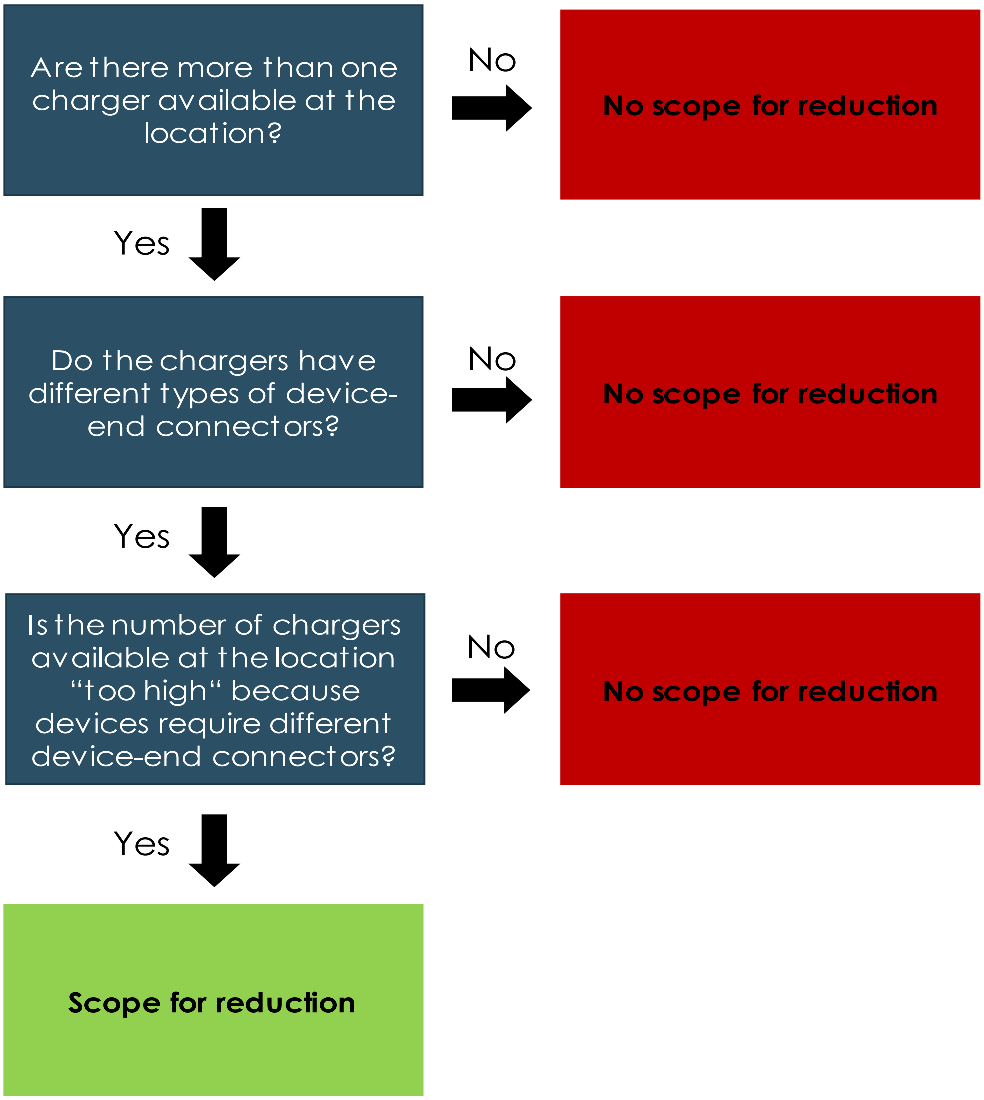
70 For instance, Apple offers adaptors so that consumers can use micro-USB cables to charger their phones: https://www.apple.com/shop/product/MD820AM/A/lightning-to-micro-usb-adapter

71 Only 0.05% of all mobile phones were sold without a charger in 2013.

In doing so, we look in detail into consumers' current preferences for chargers and how they would change if a Common Charger, with complete reduction in device-end connector heterogeneity, would be introduced. Specifically, it is important to map out in detail how consumers view the scope for reducing the number of chargers they have and use if all devices were to use the same type of device-end connector for charging.

As illustrated in Figure 25, a Common Charger will only have the potential to impact charger reduction at locations where consumers currently have more chargers than they optimally would want to have, because their devices require different types of device-end connectors.

Figure 25
Conceptual illustration of situations where a Common Charger reform could lead to a reduction in the number of chargers consumers have



Source: Copenhagen Economics

As a simple example, this would be the case for a consumer that has two devices where one requires a USB Type-C device-end connector and the other requires a Lightning device-end connector and, importantly, the consumer would prefer to only have one charging cable for those two devices but is currently restricted by the fact that they require different types of device-end connectors.

If the consumer, on the other hand, prefers two charging cables for the devices to be sure that they can be charged simultaneously, then a Common Charger would not lead to a reduction in the number of chargers the consumer chooses to have.

4.4 CONSUMER DEMAND FOR CHARGERS WOULD DECREASE ONLY MARGINALLY IF THE COMMON CHARGER IS INTRODUCED

In the end, consumer demand and preferences determine the number of chargers that are produced and sold – the number of chargers produced will not fall below consumers' demand for chargers.

The introduction of a Common Charger may lower the demand for chargers thanks to higher interoperability between chargers and devices. This would, in turn, lower the supply of chargers. Thus, the environmental benefits of reduced electronic waste and material use are determined by the potential change in consumers' demand for chargers if a Common Charger is introduced.

We compare the current demand for chargers (status quo) with a counterfactual scenario where a Common Charger is introduced. We do not make any assumptions about decoupling rates but instead focus on a counterfactual demand for chargers in a world where all chargers fit all mobile electronic devices (excl. laptops[72]). The fact that production of chargers will never fall below demand, makes it particularly interesting to study habits and demand of consumers in a counterfactual scenario with a Common Charger.

The demand in the counterfactual scenario will provide an upper bound for the reduction of produced chargers, and thereby an upper bound for the reduction in CO_2-equivalent emissions. It is an upper-bound estimate because even though a consumer would prefer to have fewer chargers than devices, if a charger is provided in-the-box with a new device the consumer would still end up with more chargers than he/she prefers.

In order to estimate the demand for chargers in the counterfactual scenario we have conducted a consumer survey on charging habits and preferences to help us to estimate the counterfactual demand.

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[72] There are two main reasons for excluding laptops from the analysis: The first is that there is greater heterogeneity in the types of available laptop chargers on the market today, although the introduction of the USB Type-C cable may turn out to bring about a decrease in the laptop charger heterogeneity during coming years. Thus, the status quo scenario is very different for laptops than it is for other mobile devices. The second is that the interchangeability of a charger for smaller mobile devices and laptops is limited, even though they would use the same type of device-end connector. A laptop battery requires a higher voltage than batteries of smaller mobile devices. Using a mobile phone charger to charge a laptop will be very slow and the battery charge will not last long once unplugged. Using a laptop charger to charge a mobile phone may be inconvenient if the laptop charging block is bulkier than the charging block required for mobile phones. In addition, the Commission's Inception Impact Assessment does not mention laptops as a potential type of device to be included in the initiative, though that does not rule out that laptops may be included in the scope of the Common Charger initiative further on.

4.4.1 Estimation of demand for charging cables with and without a Common Charger

If a Common Charger is introduced it is possible that some consumers will choose to have fewer chargers than they currently have today because of the increased interoperability between chargers and devices. At the extreme, consumers can, at least in theory, charge all their different devices with one charger i.e. use and carry a single cable for all their needs, at all times and all locations.

It is also possible that some consumers will choose to have the same number of chargers that they currently have, even with a Common Charger. Consumers may find it convenient to charge different devices at the same time or prefer to keep chargers at different locations. A consumer with a mobile phone may prefer to have one charger at home, one in the car and one at the office, instead of having (and remember) to carry a charger around.

So, the fact that there is more than one type of device-end connector available on the market may impact the number of chargers the average household chooses to have, but the extant literature does not measure to what extent. If consumers prefer to have many chargers at their disposal for convenience matters not related to the different types of device-end connectors, it follows that a substantial reduction of chargers produced will not be achieved with a Common Charger reform.

Our analysis focuses only on charging cables, rather than charging blocks. The reason is that almost all cables today are detachable from the charging block and that almost all charging blocks are using the USB type-A port to connect with the cable.[73] A consumer with two devices using cables with different device-end connectors (for example one device using the Lightning cable and one device using a USB Micro-B cable) would currently be able to use only one charging block for both cables, since they both have a USB Type-A block-end connector. Note that some charging blocks include multiple USB-A slots, and some wall-side appliances (in homes, offices, hotels etc) have direct USB-A ports at the wall or table. Thus, our analysis holds the overall number of charging blocks unvaried.[74]

Importantly, since chargers are typically included in the box when a new device is purchased, chargers differ from most other consumer goods and services. It may therefore be misleading to interpret the actual sales of standalone (i.e. additional) chargers as a useful proxy for the actual demand for, or use of, chargers. Besides, standalone chargers represent a very small share of total charger sales.[75]

Our survey was designed specifically so to provide evidence of the number of charging cables in use today and the change in demand for charging cables directly caused if a Common Charger is introduced. We will use the survey results to calibrate different inputs to our demand estimation. The result of the survey will be presented in section 4.4.2 and the entire survey questionnaire can be found in Appendix A.

73 European Commission, 2018, *Common chargers for mobile telephones and other compatible devices*.

74 However, if a Common Charger is to be based on the USB type-C connector at the charging block-end, the transitory period of moving from charging blocks with USB type-A connectors to charging blocks with USB type-C connectors may lead to a transitional increase in demand for charging blocks as consumers replace their current charging blocks with the new USB Type-C charging blocks. This transition is largely unrelated to any device-end connector mandate and is beyond the scope of this analysis.

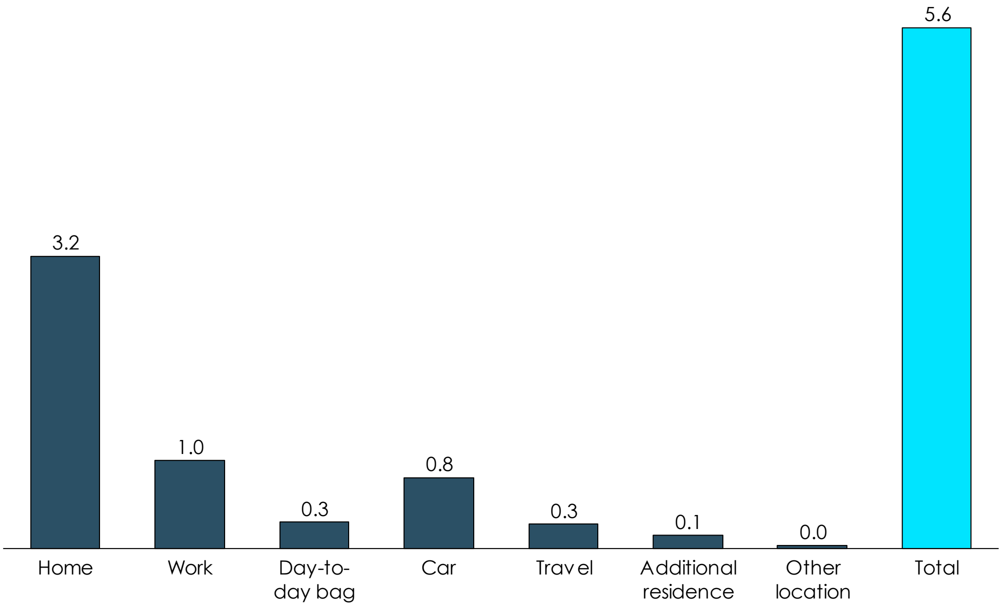
75 See footnote 71.

4.4.2 Survey Evidence: Current charger demand and user preferences

As we have previously shown, the average EU household has 5.6 charging cables, used to power 5.4 mobile devices (cf. Figure 11). Thus, the average EU household has 1.04 charging cables per mobile device.

The majority of the charging cables are located at home, cf. Figure 26, corresponding to approximately 60 per cent of the stock of charging cables. The home is the only location where the average household has more than one charging cable, thus with a scope of reducing the number of cables in the Common Charger scenario.

Figure 26
Average number of charging cables at different locations
Number of charging cables



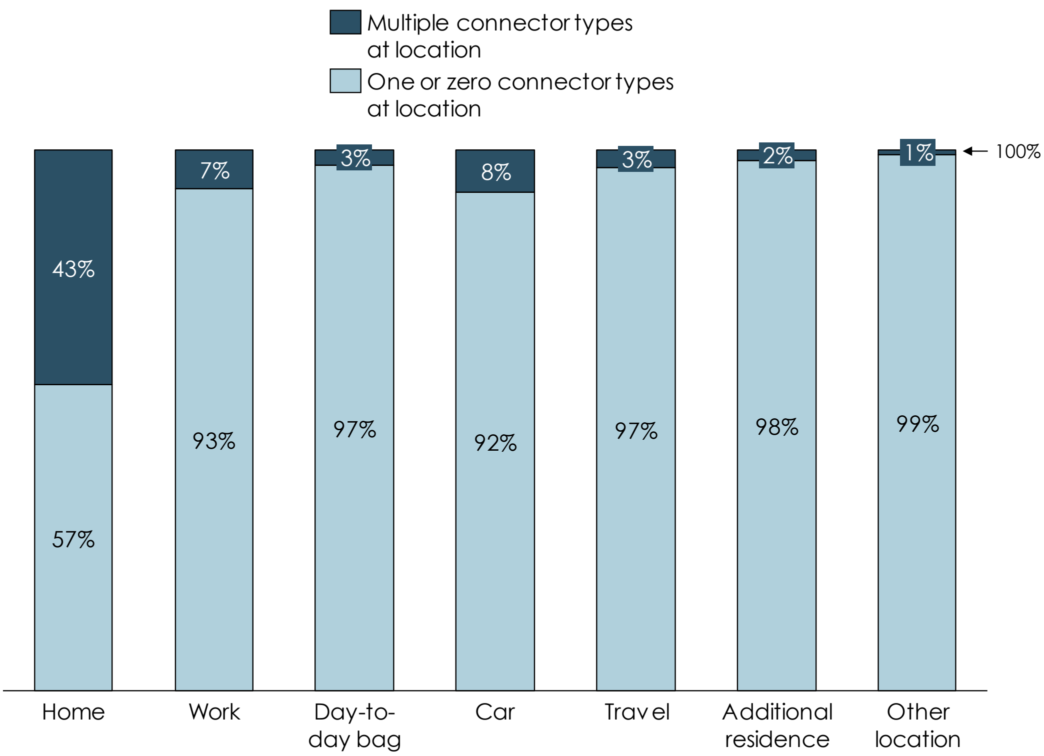
Note: Question to respondents: How many dedicated charging cables do you and your household have in regular use (i.e. used at least once during the past 12 months) at the following locations?
Source: Copenhagen Economics

If there is only one cable residing in a location, it is because the consumer needs or prefers to have a charger at the location. Such a need should not be affected by the Common Charger initiative, as there can be no lack of interoperability with only one cable.

In order for the Common Charger initiative to contribute to a reduction in cables, it is also necessary that the cables at the location have different device-end connectors. If a household currently has multiple cables, all with the same device-end connector type, it reflects the consumer preference of having that number of charging cables. If, on the other hand, there is more than one type of device-end connector at the location, this may reflect an involuntarily high number of charging cables, due to devices requiring different types of device-end connectors.

Figure 27 reflects that it is primarily at home where there are instances of multiple types of device-end connectors, while fewer than ten per cent of the households have multiple types of chargers at other locations. Still, **already today (without any regulation forcing a single connector type), almost 60 per cent of households have only one type of device-end connector at home**.

Figure 27
Share of households with one or multiple types of device-end connectors, by location
Per cent



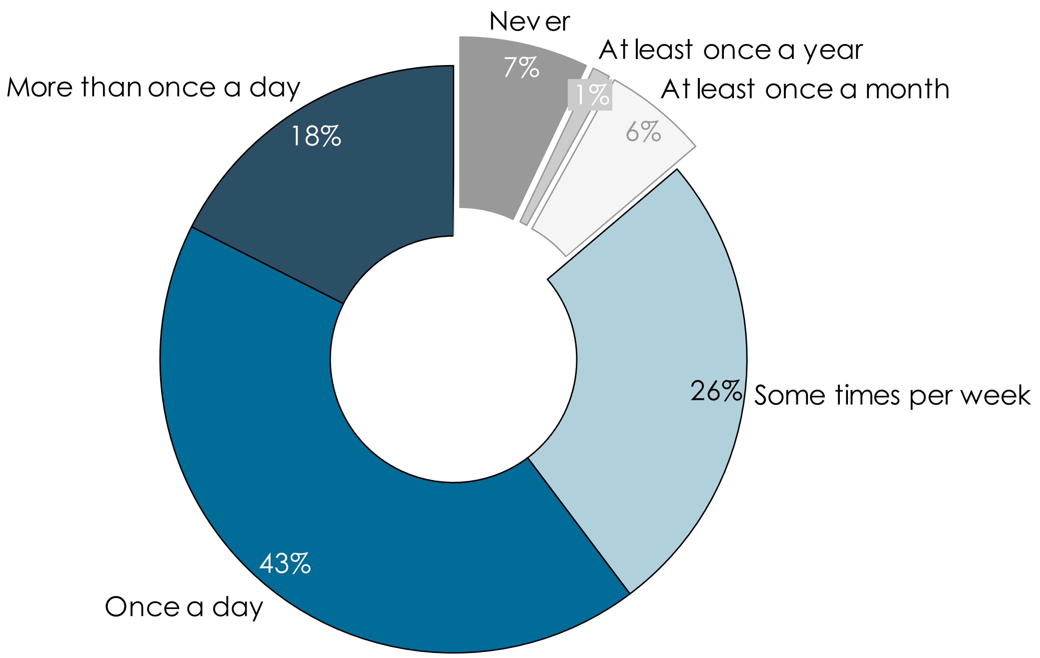
Note: Question to respondents: Number of cables at [location] [numbers per connector type]?
Source: Copenhagen Economics

As it is only at home that the average household has more than one charging cable, we dig deeper into the charging behaviour to assess how common it is that multiple charging cables are used simultaneously. This could, for example, be the case if a household charges multiple devices during the night or at the end of the workday.

The more often households use multiple cables at the same time, the more restricted they are in their potential reduction of cables in a Common Charger scenario. A household that charges two devices during the night needs two cables, regardless of whether the devices require the same or different types of device-end connectors.

87 per cent of households report that they charge multiple devices at the same time at least some times per week, while over 60 per cent do it on a daily basis, cf. Figure 28. This suggests that consumers' choice to have more than one charger per location is for practical reasons and not only because of lacking interoperability between devices and chargers.

Figure 28
Frequency of charging multiple devices at the same time while at home
Per cent



Note: Question to respondents: How often do you and your household members charge multiple devices at the same time while at home (e.g. in the evening, at the end of the daily activities, overnight, etc.)?
Source: Copenhagen Economics

4.4.3 Survey evidence: Reduction in the number of cables if the Common Charger is introduced

After establishing the current charging cable preferences and behaviours, we have asked respondents to state how many fewer charging cables they would choose to have at different locations if a Common Charger is introduced in the EU.

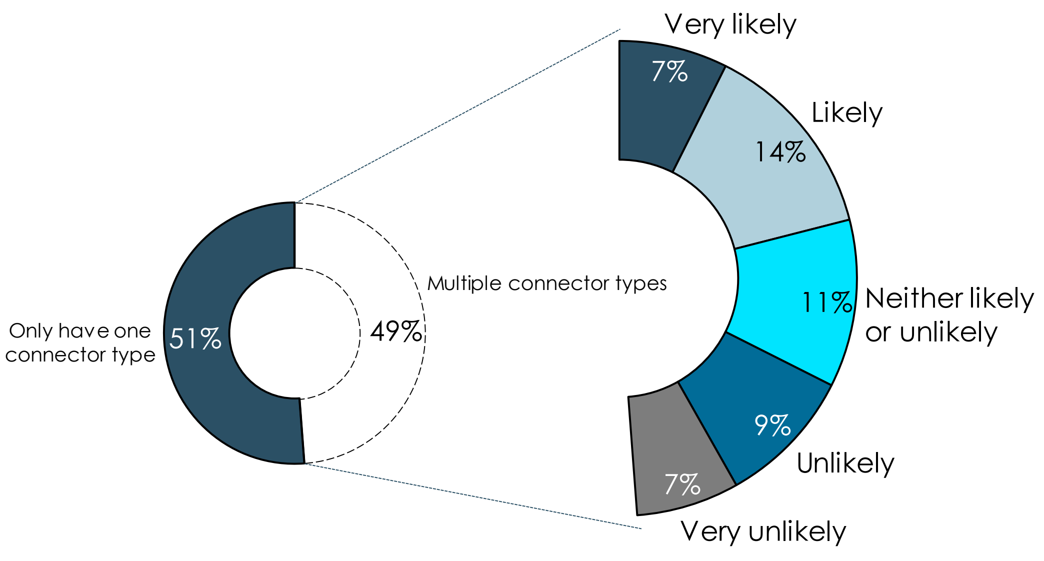
While the results in section 4.4.2 suggest that there is limited scope for cable reduction, given the number of cables at different locations, the types of device-end connectors and frequency of charging multiple devices at the same time, it is still possible that consumers foresee a scope for reducing the number of cables they use. For example, a household that on a daily basis charges two devices that require different types of device-end connectors may prefer to adjust their charging habits if they could use one single cable for those two devices.

Therefore, all consumers that have at least two different types of device-end connectors (regardless of location of the cable) were asked about how they view the scope for reducing the number of cables, if the EU Common Charger is introduced. However, households that only have one type of device-end connector were not asked these questions, as by logic they cannot be expected to reduce the number of cables they have, as an effect of the Common Charger – their current situation is the same as the Common Charger situation, whereby all cables fit with all devices.

Our survey provides a unique data point to clarify this important empirical matter. Based on EU consumers responses, we find that **51 per cent of households are already currently in a situation where the entire household relies on a single charging cable type** to serve their set of mobile, tablets and other related electronic devices. In other words, more than half of EU households would be completely unaffected by an EU Common charger initiative: based on their free choice on the market, these households live already in a single charger product ecosystem for the devices analysed in this study.

Thus, the only domain over which an EU Common charger initiative may bring fruit (e.g. in cable demand reduction and related environmental benefit) is over the less than half of EU households which currently use devices with different connector types.

Figure 29
Likelihood of reducing the household's number of cables
Per cent



Note: Due to the rounding of numbers, the shares on the likelihood of cable reduction sum to 48 instead of the actual 49 per cent. Question to respondents: Now consider a situation where all the mobile devices in your household (and work) would use the same type of device plug. In this situation, how likely is it that you and your household members would reduce the number of charging cables you find it convenient to use on a regular basis?

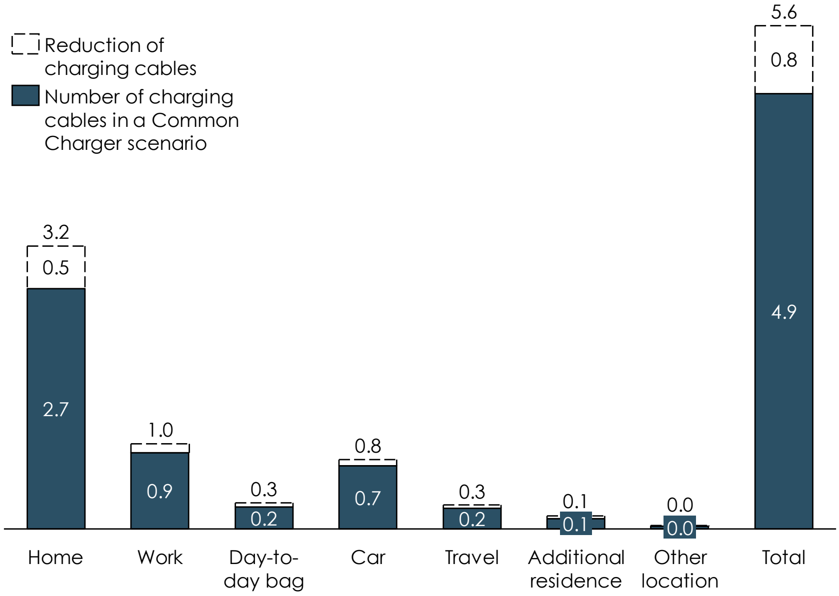
Source: Copenhagen Economics

Our survey has put the question in front of EU consumers. Out of all households, 49 per cent of households are such that a reduction in demand for and thus use of chargers is possible, if they were led to turn to a single connector type for all their devices. However, only 21 per cent of respondents report that they are likely or very likely to reduce the number of cables they have, if the Common Charger is introduced, while 11 per cent report that cable reduction is neither likely or unlikely.

In other words, the households where a reduction in cables demanded may in practice be possible in less than half of all households. Within these, again, less than half report a likely reduction in demand. As a result, out of all households, 67 per cent are either unlikely, very unlikely or unable to reduce the number of charging cables they have (cf. Figure 29).

In order to obtain a number on the reduction in the number of cables, the respondents who reported that they were very likely, likely, and neither likely or unlikely were asked to specify how many fewer cables they would choose to have if the Common Charger is introduced, compared to their current stock of charging cables across different locations. Based on the information about reduction from those respondents that report that they are at least neither likely or unlikely to reduce the number of charging cables they have, we are able to calculate the average reduction of charging cables across all households in the EU.

Figure 30
Average reduction in the number of charging cables across locations
Number of charging cables



Note: Due to the rounding of numbers, the total cable reduction per household is presented as in the bar graph above, however, the actual total reduction is from 5.62 cables down to 4.86 cables, i.e. a reduction of 0.76 cables. Question to respondents: Consider again the situation where all the mobile devices in your household (and work) would use the same type of device plug. For every location below, what, if any, would be the reduction in the number of charging cables you and your household members would find it convenient to use on a regular basis in such a situation, compared to the current situation? We would reduce the number of charging cables by… [reduction of cables per location]

Source: Copenhagen Economics survey

The average EU household would prefer to have 4.9 charging cables instead of the current 5.6 cables, implying a reduction of 0.8 units of charging cables per household if the EU Common Charger is introduced, cf Figure 30. This means that the average EU household would reduce the number of charging cables that they have in regular use by 14 per cent.

Households that currently have more than one type of device-end connector – just under a half of all households – would reduce their current 7.6 cables down to 6 cables, a reduction of 1.6, i.e. of 21%. Just over a half of all households already have only one type of device-end connector and cannot reduce the number of cables in a scenario with the Common Charger, as all their mobile and related devices have already the ability to use the same connector type.

It is primarily at home that households would reduce the number of cables they have, going from 3.2 to 2.7 cables. This is not surprising, given that the majority of cables that households have are located at home, and it is also the location where households typically have more than one type of device-end connector.

Overall, households currently have 1.04 charging cables per device (cf. Figure 11), and in the Common Charger scenario, households would choose to have 0.9 charging cables per device – equivalent to a 14% decrease in this key ratio.

It should be noted that the reduction in cables reported here represents an upper bound of the actual reduction in charging cables if the Common Charger is introduced. The reduction from 5.6 cables to 4.9 cables represents the true consumer demand for chargers, while in practice it may still be the case that households end up with more cables than that, e.g. if cables are provided in-the-box whenever a device is purchased even though the consumer already has a functioning cable available.

It should also be noted that there is an ongoing transition in the market, where consumers are shifting away from USB Micro Type-B to USB Type-C. This yields a trend going both ways: one effect is for households to be currently expanding the range of connector types in use (as USB C is adopted); another effect is households that already have both USB Micro Type-B and USB Type-C connectors, could over time completely remove all USB Micro Type-B connectors and thus possibly converge out of their own preference and market forces onto a single connector type.

A closer inspection reveals that households that currently have USB-Micro Type B and USB Type-C connectors (16 per cent of the households, cf. Figure 12) is the group that will reduce their number of cables the most in the Common Charger scenario (26 per cent fewer cables).

4.5 THE REDUCTION IN CO_2-EQUIVALENT EMISSIONS FROM REDUCED CHARGER DEMAND IS LIMITED

As stated already in section 2.3, we need a consistent future time interval over which to evaluate future impacts on cable reduction and related CO_2-equivalent emissions from reduced production. We set this interval at seven years in order to allow for a comparison with the loss of consumer welfare from a 4-year delay in the market introduction of innovation, as reported in section 2.3.

Table 4
Parameters and results for calculating the reduction in consumer demand for charging cables if the Common Charger is introduced

Variable	Formula	Value	Label	Source
Number of households in the EU (excl. UK), annual average 2022-2028		202 mn.	A	CE forecast based on Eurostat[76]
Cables per household, current situation		5.6	B	CE survey (Figure 30)
Cables per household, Common Charger situation		4.9	C	CE survey (Figure 30)
Total annual demand (stock) for charging cables in the EU (excl. the UK), current situation	A*B	1,139 mn.	D	CE calculation
Total annual demand (stock) for charging cables in the EU (excl. the UK), Common Charger situation	A*C	985 mn.	E	CE calculation
Reduction in annual demand (stock) for charging cables in the EU (excl. the UK) in the Common Charger situation	**D-E**	**154 mn.**	**F**	**CE calculation**

Note: See Appendix B for sensitivity tests regarding the above results.
Source: Copenhagen Economics

Based on the survey results where households reported that they currently have 5.6 charging cables on average and would reduce that number to 4.9 charging cables if the Common Charger is introduced (cf. Figure 30), that would imply a total reduction in the number of charging cables demanded in the EU of 154 million. In order to assess the environmental benefit of the reduction in cables, we assess the NPV of the reduction in CO_2-equivalent emissions stemming from reduced production of charging cables for the EU market.

[76] Eurostat, Number of private households by household composition, number of children and age of youngest child (1 000).

Table 5
Parameters and results for calculating the environmental benefit from reduced production of charging cables

Variable	Formula	Value	Label	Source
Reduced annual demand for charging cables in the EU (excl. the UK)		154.2 mn.	A	Table 4
Replacement cycle (i.e. how often the cable stock needs to be replaced)		2 years	B	CE assumption
Reduced annual sales of charging cables in the EU (excl. the UK)	A/B	77.1 mn.	C	CE calculation
CO_2-equivalent emissions per charging cable		0.6 kg.	D	Production data from Apple[77]
Reduction in CO_2-equivalent emissions from reduced sales of charging cables in the EU (excl. the UK) over a 7-year period	C*D*7	324,000 tonnes	E	CE calculation
Socio-economic value per tonne of CO_2-equivalent emissions		€ 53	F	UK BEIS[78] average during a 7-year period
Socio-economic value of reduction in CO_2-equivalent emissions from reduced sales of charging cables in the EU (excl. the UK)	E*F	€ 17.2 mn.	G	CE calculation
Social discount rate		4%	I	EU Better Regulation Toolbox 61
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	**See note**	**€ 13.3 mn.**	**J**	**CE calculation**

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where *i* denotes the year and *r* is the social discount rate. See Appendix B for sensitivity tests regarding the above results.

Source: Copenhagen Economics

The reduction in the total number of charging cables that EU households would need or prefer to have each year is 154 million, thus implying that those cables need not be produced to satisfy EU demand. The reduced production leads to reduced CO_2-equivalent emissions from production.

However, as there is no available evidence on the average lifetime of charging cables in the EU, we assume that each household's stock of chargers is replaced every second year. This is likely a very short replacement cycle, as it means that a household that uses e.g. six charging cables would purchase three charging cables every year in order to maintain their stock of six chargers. If the actual replacement cycle of charging cables is longer than two years, the environmental benefit of the Common Charger is lower than reported in Table 5 (see Table 17 in Appendix B).

The reduced production implies reduced CO_2-equivalent emissions of 324,000 tonnes, over the seven-year assessment period. By applying the forecasted development in short-term traded carbon values of the UK's Department for Business, Energy & Industrial Strategy,[79] and a social discount rate of four per cent,[80] **the environmental benefit of the Common Charger expressed in monetary terms is 13 million euro (NPV).**[81] As a comparison, the value of the CO_2-equivalent emissions from the EU passenger car traffic (excluding the UK) in 2017 alone amounted to 6 billion euro.[82]

4.6 THE COMMON CHARGER MAY LIMIT ENVIRONMENTAL INNOVATION

Manufacturers of mobile devices have strong visions and a significant pressure from consumers, society and regulators to achieve a more sustainable production and become more environmentally friendly. To reach these targets, manufacturers take initiatives to reduce usage of raw material and the CO_2-emission in production of devices and chargers.

Furthermore, they introduce new innovative charging systems that are more energy efficient than their predecessors, thereby reducing the energy consumption of devices throughout their lifetime. These efforts may appeal to a growing environmental consciousness of some customers. The ability to stand out in the market against competing producers is an important parameter that drives improved environmental efficiency in charging solutions.

Apple is one of the manufacturers that has focused intensively on decreasing their environmental impact from production of devices and chargers all the way through the lifecycle of their products. The company also goes beyond what is required by law to eliminate potentially harmful chemicals from its products. In 2016, Apple launched its Full Material Disclosure program, an ambitious initiative aimed at mapping the chemical composition of every substance in every part of its products.[83] Since 2015, Apple has reduced by 35 percent its overall carbon footprint, which includes emissions

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77 Calculated with Apple's carbon lifecycle assessment model, the same model used for other Apple product carbon footprint analyses (see https://www.apple.com/environment/), using industry average data. In addition, it is worth noting that producing a USB-C-to-USB-C cable leads to a 20 per cent larger CO_2 footprint than a USB-C-to-Lightning cable.

78 Department for Business, Energy & Industrial Strategy, 2019, *Updated short-term traded carbon values*, central forecast estimates 2020-2030.

79 Department for Business, Energy & Industrial Strategy, 2019, *Updated short-term traded carbon values*.

80 European Commission, Better Regulation Toolbox 61.

81 This calculation does not take into account that producing cables with a USB Type-C connector at both ends of the cable leads to a 20 per cent larger CO_2 footprint than producing cables with a USB Type-C connector at the charging block-end and a Lightning connector at the device-end of the cable, due to the USB Type-C connector being larger and having a higher mass than the Lightning connector, see Figure 17 and footnote 77.

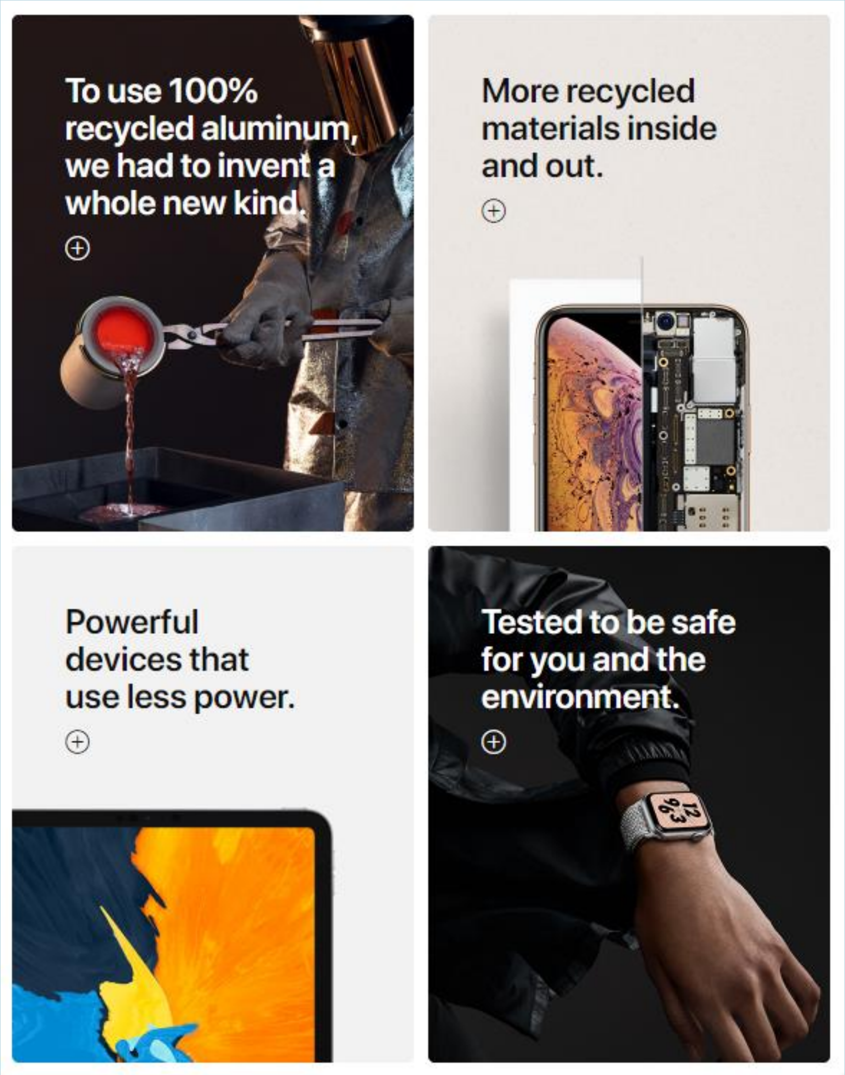
82 Eurostat, Greenhouse gas emissions by source sector (source: EEA).

83 Apple Regulated Substances Specification, available at: https://www.apple.com/environment/pdf/Apple_Regulated_Substances_Specification_March2016.pdf.

from the entire product lifecycle, primarily through transitioning to renewable energy at its own facilities and in its supply chain, as well as through product design changes, cf. Box 3.

Box 3 Case study: Apple's reduced carbon footprint while maintaining a viable consumer offering

According to Apple's environment reports, the company takes responsibility for products throughout their life cycles—including the materials they are made of, the people who assemble them, and how they are recycled at end of life. Apple is committed to using carbon life cycle assessments to identify opportunities to drive down product greenhouse gas emissions and focuses on making energy-efficient products with renewable or recycled materials and with renewable energy. It reports to the public annually on its environmental impact while also providing reports on new products.



Source: https://www.apple.com/environment/

In addition, Apple has removed many harmful substances from its product designs[84], and producing a Lightning connector requires less than half the material input compared to producing a USB Type-C connector (cf. Table 6). The environmental benefit calculations in the previous section shall thus be seen as upper bound estimates, since they do not take into account that all Lightning cables and connectors would have to be replaced by cables and connectors that lead to larger emissions from production (due to, among other factors, the USB Type-C cable and connector standard's support for higher power levels as compared to Lightning).

Table 6
Material use comparison table, Lightning and USB Type-C

MM^3	LIGHTNING			USB TYPE-C		
	Receptacle	Connector	Total	Receptacle	Connector	Total
Injection moulding Plastic	187	239	**426**	172	975	**1,147**
Metal injection moulding, stainless steel	0	41	**41**	34	0	**34**
Stamped stainless steel	21	26	**47**	55	112	**167**
Stamped copper	6	0,3	**6,3**	6	8	**14**

Source: Apple

Furthermore, improvements and innovation have also increased the energy efficiency of chargers. For example, the introduction of Apple's 30-pin charger – the predecessor to the Lightning charger – brought many new features but one of the more significant improvements was the ability to transfer data in an energy-efficient way. Each of the 30 pins had its own task, meaning that when an iPhone was connected to a speaker dock, for example, the speaker only tripped the pins it needed: audio out and power in.

The idea of assigning pins to different tasks still exists today and has been adopted by modern technologies such as Lightning and USB Type-C. Both Lightning and USB Type-C use fewer pins – further reducing material use, weight and breakage rates.

Another charger innovation that has saved energy is the transformation from "hot" charging systems to "cold" charging system. The USB Type-A is a "hot" system, meaning that power runs through the cables even when no device is plugged in. On the other hand, USB Type-C is a "cold" system that only transfers power when a device is connected.[85]

[84] Apple Regulated Substances Specification, available at: https://www.apple.com/environment/pdf/Apple_Regulated_Substances_Specification_Sept2018.pdf.
[85] Charles River Associates (CRA), 2015, *Harmonising chargers for mobile telephones*, page 17.

It is unlikely that we have yet reached peak energy-efficiency in chargers as more improvements are continuously being introduced to the market. Earlier this year, Xiaomi announced that they had developed a new charging system that would reduce the charging time of a smart phone from approximately one hour to only 17 minutes while saving 4 percent energy compared to other chargers.[86]

As stated previously in this report, the introduction of a Common Charger does not *per se* constrain manufacturers from improving production or make innovative improvements within the selected standard. However, as was the case with the slow development of the USB Type-C cable and connector,[87] a regulatory mandated standard may delay the roll-out of new innovations as they have to be agreed upon and approved by the regulatory bodies.

Furthermore, the Common Charger standard is unlikely to be limited to the physical shape of the device-end connector but also a number of other relevant features, such as voltage, audio, and video requirements. Thus, it is unclear whether e.g. improved charging system solutions within the USB Type-C standard would be able to be realised with a Common Charger. As producers research and launch innovation in order to gain competitiveness in the market, having the same chargers for every device decreases the ability for firms to reap commercial benefits of environmental improvements.

Most importantly, the Common Charger may not just delay but prevent future environmental innovations. Whether it is done within a proprietary device-end connector standard or within the USB standard, the Common Charger risks taking away the important incentive of allowing an innovative firm to launch the new, improved, environmentally-friendly charger before its competitors. While the Commission has stated that any Common Charger initiative "*shall be future-proof by taking into account innovation aspects*"[88], it is unclear how the most intrusive scenario – a single device-end connector mandate – would allow for innovation in any realistic manner.

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86 The Next Web, 26 March 2019, *Xiaomi's new 100W charger will charge your phone in just 17* minutes, available at: https://thenextweb.com/plugged/2019/03/26/xiaomis-new-100w-charger-will-charge-your-phone-in-just-17-minutes/

87 Macworld, 3 November 2017, *USB-C vs Lightning*, available at: https://www.macworld.co.uk/feature/mac/usb-c-vs-lightning-3666439/.

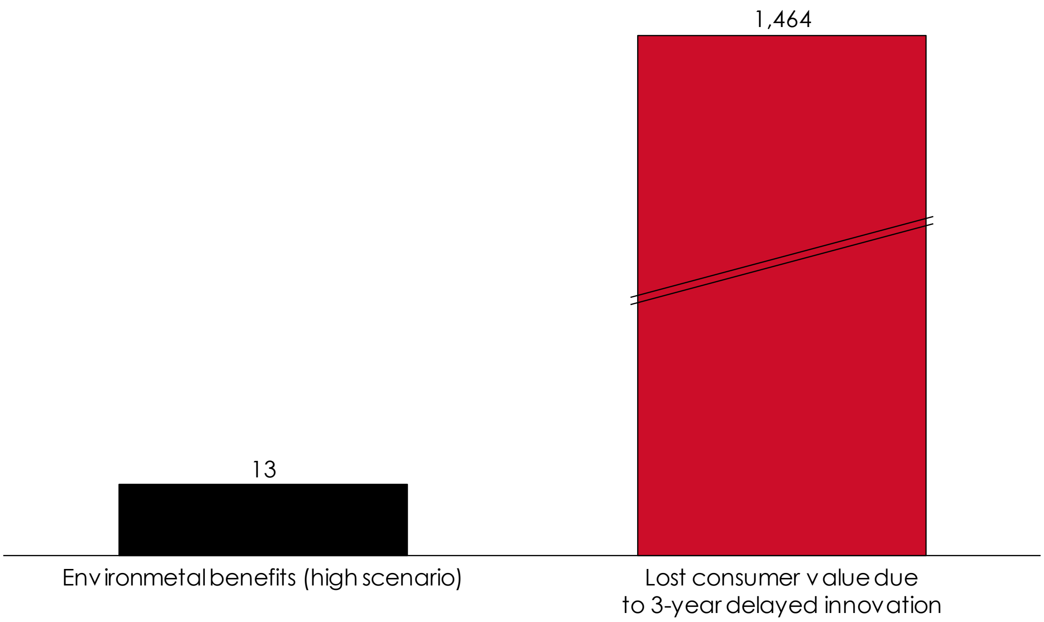
88 European Commission, 2018, *Inception Impact Assessment: Common chargers for mobile telephones and other compatible devices*, Ref. Ares(2018)6473169 – 15/12/2018, p. 3.

CHAPTER 5

CONCLUDING REMARKS

This report has shown that a Common Charger puts significant consumer value at risk, at least € 1.5 billion in NPV (over seven years), due to its restrictive or delaying impact on innovation. The loss of consumer value far outweighs the environmental benefits of a reduction in consumer demand for cables which is € 13 million in NPV (over seven years), cf. Figure 31. As the survey results show, it is unlikely that a Common Charger would lead to a substantial reduction in consumer demand for chargers.

Figure 31
Value of environmental benefit and lost consumer value from delayed innovation
Million euro, NPV



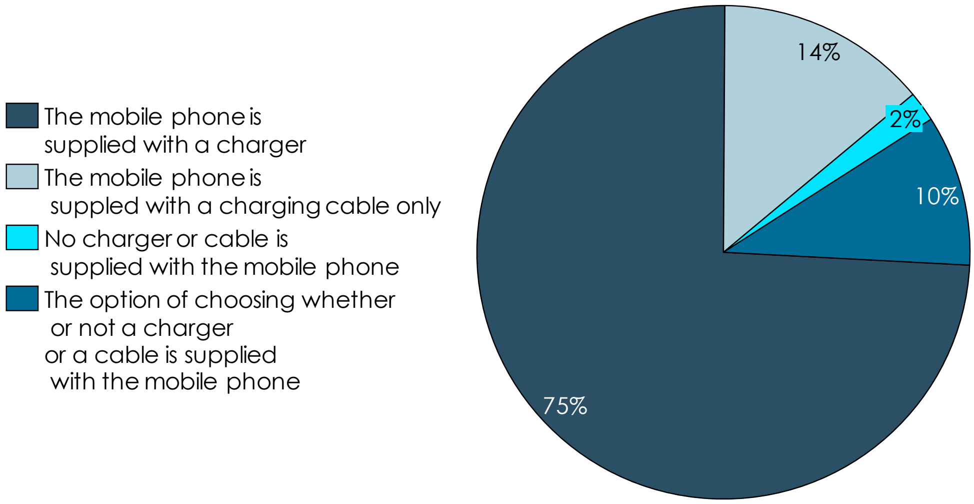
Note: A discount rate of 4 per cent is used for calculating the net present value (NPV, over seven years).
Source: Copenhagen Economics. The environmental cost saving is calculated based on BEIS 2019-estimate for short-term traded values of CO_2 (see footnote 78).

Thus, as previous analyses have shown,[89] [90] an increased practice of decoupling, i.e. that chargers are not provided in-the-box whenever a mobile device is purchased, may lead to a relatively larger reduction in the number of sold chargers, as reviewed in sections 4.2 and 4.3 of this report.

[89] Risk & Policy Analysts (RPA), 2014, *Study on the Impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*.
[90] Charles River Associates (CRA), 2015, *Harmonising chargers for mobile telephones - Impact assessment of options to achieve the harmonisation of chargers for mobile phones*.

Each manufacturer has an incentive to supply a charger sold together with every new device, in order to avoid a situation where a consumer may be inconvenienced, for a small relative cost saving (the cost of providing a charger is always a small fraction relative to the devices themselves). As results from a recent consumer survey shows, still today, consumer preferences are such that consumer demand pressures manufacturers to supply chargers together with each new device, given the incentive to serve demand needs (cf. Figure 32).

Figure 32
Consumers' preferred solution when purchasing a mobile phone
Per cent



Note: Question: When buying a mobile phone, which of the following options do you prefer the most?
Source: Risk & Policy Analysts (RPA), 2019, *Study on the Common Charger 2.0*.

Notwithstanding this consumer preference, manufacturers and consumers may be receptive to industry-wide solutions that promote the sale of devices without an included charger (so called decoupling). Decoupling is a supply-side measure, and our study empirical focus (centred upon demand-side) does not seek to evaluate the merits of that option.

It seems that the most straight-forward way to achieve a reduction in the environmental footprint of chargers and charging cables would be to explore ways to further incentivize decoupling of devices and chargers. If successful, it may nudge consumers to demand fewer chargers, over time.

Most importantly, however, is to maximize producers' incentives to innovate and improve so that the environmental impact of production, transportation and usage of chargers can be further reduced, as reported in section 4.6.

A regulatory mandated single type of device-end connector – The EU Common Charger – is likely to entail losses of consumer value of at least €1.5 billion, while the environmental benefit amounts to €13 million. Other reforms should rather be explored, as they are likely to bring larger environmental benefits, without restricting innovation and putting significant consumer value at risk.

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APPENDIX A
SURVEY QUESTIONNAIRE

1. Do you have a smart phone (a mobile phone with internet services, apps, etc) or tablet that you use on a regular basis?

- [Yes/No]

2. How many mobile devices that require charging does your household currently use on a regular basis including both for private and work use?

Mobile phones
- [Number]

Tablets
- [Number]

E-readers
- [Number]

Cameras
- [Number]

GPS satellite navigators
- [Number]

Speakers
- [Number]

Smartwatches or other wearables
- [Number]

Other mobile devices/accessories/gadgets not specified above
- [Number]

3a. How many dedicated charging cables do you and your household have in regular use (i.e. used at least once during the past 12 months) at the following locations?

Home
- [Number]

At the workplace
- [Number]

In day-to-day bag
- [Number]

In car
- [Number]

Travel charging cable (e.g. in travel bag)
- [Number]

Additional residence (e.g. summer house)
- [Number]

At other locations
- [Number]

Not in regular use (in the past 12 months)
- [Number]

3b. How often are the charging cable(s) used at the following location?

Home
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year

At the workplace
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year

In day-to-day bag
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year

In car
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year

Travel charging cable (e.g. in travel bag)
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year

Additional residence (e.g. summer house)
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month

- Some times per year
- Once per year

At other locations

- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year

4a. Number of [cable] at home

MICRO-USB

- [Number]

LIGHTNING

- [Number]

USB TYPE-C

- [Number]

OTHER

- [Number]

4b. Number of [cable] at workplace

MICRO-USB

- [Number]

LIGHTNING

- [Number]

USB TYPE-C

- [Number]

OTHER

- [Number]

4c. Number of [cable] in your day-to-day bag

MICRO-USB

- [Number]

LIGHTNING

- [Number]

USB TYPE-C

- [Number]

OTHER

- [Number]

4d. Number of [cable] in your car

MICRO-USB

- [Number]

LIGHTNING

- [Number]

USB TYPE-C

- [Number]

OTHER

- [Number]

4e. Number of [cable] for your travel charging cable (e.g. in travel bag)
MICRO-USB
- [Number]
LIGHTNING
- [Number]
USB TYPE-C
- [Number]
OTHER
- [Number]

4f. Number of [cable] at your additional residence (e.g. summer house)
MICRO-USB
- [Number]
LIGHTNING
- [Number]
USB TYPE-C
- [Number]
OTHER
- [Number]

4g. Number of [cable] at your other locations
MICRO-USB
- [Number]
LIGHTNING
- [Number]
USB TYPE-C
- [Number]
OTHER
- [Number]

5. How often do you and your household members charge multiple devices at the same time while at home (e.g. in the evening, at the end of the daily activities, overnight, etc.)?
- More than once a day
- Once a day
- Some times per week
- Once a week
- Once a month
- Some times per year
- Once per year
- Never

6. Now consider a situation where all the mobile devices in your household (and work) would use the same type of device plug. In this situation, how likely is it that you and your household members would reduce the number of charging cables you find it convenient to use on a regular basis?
- Very likely

- Likely
- Neither likely or unlikely
- Unlikely
- Very unlikely

7. Consider again the situation where all the mobile devices in your household (and work) would use the same type of device plug. For every location below, what, if any, would be the reduction in the number of charging cables you and your household members would find it convenient to use on a regular basis in such a situation, compared to the current situation. We would reduce the number of charging cables by...

Home
- [Number]

At the workplace
- [Number]

In day-to-day bag
- [Number]

In car
- [Number]

Travel charging cable (e.g. in travel bag)
- [Number]

Additional residence (e.g. summer house)
- [Number]

At other locations
- [Number]

8. Imagine that you were offered to buy a device which is exactly as the one you currently have but with one difference: an old type of device plug and thus the set of features in the above table (such as lower speed, need for multiple data or energy cables, etc). How much cheaper would the device with the old type of device plug have to be for you to choose to buy it, instead of your current mobile device? In other words, what discount would make it equivalent to your current mobile device?

- I would not be willing to buy a mobile device (e.g. smart phone) with an old device plug regardless of the discount
- More than 30 % cheaper
- 26-30 % cheaper
- 21-25 % cheaper
- 16-20 % cheaper
- 11-15 % cheaper
- 6-10 % cheaper
- 1-5 % cheaper
- 0 % (i.e. I would pay the same price for a mobile device (e.g. smart phone) with an old device plug)

9. Now compare the movement and process of plugging in a mobile device that has a USB-C or a Lightning device plug vs an alternative type of plug that has a different size and may not be a symmetric shape of plug (i.e. not reversible: only one side works). How much faster is it for you to plug in a USB-C or a Lightning device plug compared to other types of device plugs that you have used?

- More than 5 seconds
- Circa 5 seconds
- Circa 4 seconds
- Circa 3 seconds
- Circa 2 seconds
- Circa 1 second
- 0 seconds (no difference)

10. Consider your current enjoyment and convenience of using mobile devices. How interested are you in more innovation and improvements in your charging experience of mobile devices in the future?

- Not interested at all
- Not interested
- Somewhat interested
- Interested
- Very interested

11. Do you think it would be a good policy to require all mobile phones and other similar devices to have the same type of device plug, if it meant one or several of the above implications, i.e. side effects?

- Strongly disagree
- Disagree
- Indifferent
- Agree
- Strongly agree

HOUSEHOLD_SIZE

- [Number]

APPENDIX B

SENSITIVITY TESTS

In chapter **Error! Reference source not found.** and chapter 4.5, we calculate the impact of the C ommon Charger regulation forcing a single device-end connector type, on future consumer value due to delayed innovation and the value of a reduction in CO_2-equivalent emissions from reduced consumer demand for charging cables, respectively. The variables, parameters and calculations are described in Table 3, Table 4 and Table 5. In this appendix, we perform a number of sensitivity tests to understand how the results vary if we employ different values or calculation methods.

Firstly, we report the sensitivity testing of how consumer value will be impacted due to a delay in future innovation. We change the parameters one at a time, keeping all other parameters as in the central case presented in chapter **Error! Reference source not found.**. The sensitivity test results can be compared to the central result of a consumer value loss of **€1.5 billion**.

Secondly, we report the sensitivity testing of the value of a reduction in CO_2-equivalent emissions. Again, we change the assumptions one at a time, keeping all other assumptions as in the central case presented in chapter 4.5. The sensitivity test results can be compared to the central result of an environmental benefit of **€13.3 million**.

SENSITIVITY TESTS OF THE LOSS OF CONSUMER VALUE DUE TO DELAYED FUTURE INNOVATION

Lower consumer value from future innovation

Our central result is calculated based on the value that EU consumers attribute to past charging solution innovations: 18% of the device price. However, as it is inherently difficult, if not impossible, to know how consumers will value future innovation, we test what the loss of consumer value will be from a three-year delay in innovation if the consumer value of future innovation in the charging solution is only half of the past value, i.e. 9%. Accordingly, the loss of consumer value due to a three-year delay in future innovation is €0.7 billion (i.e. €700 million.)

Table 7
Sensitivity test: Lower consumer value of future innovation than past innovation

	Half of central scenario
EU consumer value attributable to the new innovation as share of device price	9%
NPV loss of consumer value due to a 3-year delay in innovation	€ 0.7 bn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate
Source: Copenhagen Economics

Different time span

Our central result is assessed over a 7-year time period, corresponding to the same number of years between the launch of the first state-of-the-art modern device-end connector and the last full year with sales data, i.e. 2012-2018. Therefore, we also test the loss of consumer value of a three-year delay in innovation over a 5-, 6-, 8- and 9-year time period. We find that the loss of consumer value of a three-year delay in innovation ranges from €0.8 billion with a 5-year time span to €2.3 billion with a 9-year time span.

Table 8
Sensitivity test: Different lengths of the assessment period

Time span	5 years	6 years	8 years	9 years
NPV loss of consumer value due to a 3-year delay in innovation	€ 0.8 bn.	€ 1.1 bn.	€ 1.9 bn.	€ 2.3 bn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.
Source: Copenhagen Economics

Country specific consumer value attributable to the new innovation

Our central result is calculated using a weighted average of the EU consumer value attributable to past innovation, 18%, based on our survey results from France, Germany, Italy, Poland and Sweden. Here, we calculate the loss of consumer value from a three-year delay in future innovation, applying the consumer value attributable to past innovation from each of the surveyed countries. The loss of consumer value from a three-year delay in future innovation ranges from €1.3 billion using the Italian consumer value attributable to past innovation to €2 billion using the Swedish consumer value attributable to past innovation.

Table 9
Sensitivity test: Country-specific consumer value attributable to the new innovation

Country	France	Germany	Italy	Poland	Sweden
Consumer value attributable to the new innovation as share of device price	18%	18%	15%	18%	24%
NPV loss of consumer value due to a 3-year delay in innovation	€ 1.5 bn.	€ 1.5 bn.	€ 1.3 bn.	€ 1.5 bn.	€ 2.0 bn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.
Source: Copenhagen Economics

Including the UK in the EU

In our central result we exclude the UK market from the EU-wide loss of consumer value. Had we included UK, the number of devices sold in the assessment period would have been 1.2 billion, instead of 994 million. Correspondingly, the loss in consumer value from a three-year delay in future innovation would have been €1.8 billion with the inclusion of also the UK market.

Table 10
Sensitivity test: Including the UK market into the EU-wide loss of consumer value

	Including the UK in sample
Sales of smartphones in the EU (incl. UK) during a 7-year period	1,158 mn.
NPV loss of consumer value due to a 3-year delay in innovation	€ 1.8 bn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Using same time span for delayed innovation
In the central scenario we assess the loss of consumer value from a three-year delay in innovation compared to no delay in innovation, over a 7-year time period, respectively. Here, we calculate the loss of consumer value over a given number of years, 2022-2028. Thus, we assume that an innovation is launched in 2022 in the status quo scenario, while in the Common Charger scenario it is launched in 2025. The loss of consumer value in 2028 from the three-year delay in innovation is €8.9 billion.

Table 11
Using same time span for delayed innovation

Without delay in innovation	
Net Present Value (NPV) of consumer value of the new innovation	€ 13.2 bn.
With 3-year delay in innovation	
Net Present Value (NPV) of consumer value of the new innovation	€ 4.3 bn.
NPV loss of consumer value due to a 3-year delay in innovation	€ 8.9 bn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Price of cheapest flagship model

Our central result is based on an average smartphone price of €373. Alternatively, it is possible that a new innovation will be introduced on producers' flagship models, which typically have a higher-than-average price tag. Here, we calculate the loss of consumer value by using the price of various producers' cheapest flagship models in 2019, €589. With this price, the loss of consumer value from a three-year delay in innovation is €2.3 billion.

Table 12
Price of cheapest flagship model

	Cheapest flagship model
Average price of a smartphone in the EU in 2019	€ 589
NPV loss of consumer value due to a 3-year delay in innovation	€ 2.3 bn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

SENSITIVITY TESTS OF THE VALUE OF REDUCTION IN CO_2-EQUIVALENT EMISSIONS

High and low scenario of socio-economic value per tonne of CO_2-equivalent emissions

In our central result, we have used BEIS central scenario for the value per tonne of CO_2-equivalent emissions. BEIS also provide a high and low scenario of the value per tonne of CO_2-equivalent emissions that we apply in our calculations here. We find that the value of the reduction in CO_2-equivalent emissions ranges from €5.6 million in the low scenario to €21.0 million in the high scenario.

Table 13
High and low scenario of socio-economic value per tonne of CO_2-equivalent emissions

Time span	Low scenario	High scenario
Socio-economic value per tonne of CO_2-equivalent emissions	€ 23	€ 83
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	€ 5.6 mn.	€ 21.0 mn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Different time span

Our central result is assessed over a 7-year time period, in order to allow for a direct comparison with the loss of consumer value. Here, we redo the calculations with 5, 6, 8 and 9-year time spans. We find that the value of the reduction in CO_2-equivalent emissions ranges from €8.5 million with a 5-year time span to €18.8 million with a 9-year time span.

Table 14
Different time spans

Time span	5 years	6 years	8 years	9 years
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	€ 8.5 mn.	€ 10.8 mn.	€ 16.0 mn.	€ 18.8 mn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Country specific cables per household in current situation and Common Charger situation

Our central result is calculated by using the weighted average of cables per household in the current situation and the weighted average of cables per household in the Common Charger situation, across the surveyed consumers in France, Germany, Italy, Poland and Sweden. To examine how much our central result depends on these averages, we have calculated the value of the reduction in CO_2-equivalent emissions using the number of cables in the current situation and with a Common Charger for each of the survey countries. We find that the impact of regulation on reduction in CO_2-equivalent emissions ranges from €10.9 million when applying the reduction of cables in Germany to €20.9 million when applying the reduction of cables in Sweden.

Table 15
Country-specific cables per household in current situation and Common Charger situation

Country	France	Germany	Italy	Poland	Sweden
Cables per household, current situation	5.4	4.2	7.3	6.3	6.4
Cables per household, Common Charger situation	4.6	3.6	6.6	5.3	5.2
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	€ 14.2 mn.	€ 10.9 mn.	€ 12.4 mn.	€ 16.5 mn.	€ 20.9 mn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Including UK

In our central result we do not include the UK market from the EU-wide reduction in cables. Had we included UK, the average number of households in the assessment period would have been 233 million. Correspondingly the impact of regulation on future innovation would have been €15.3 million.

Table 16
Including UK

	Including UK in sample
Number of households in the EU (incl. UK), annual average 2022-2028	233 mn.
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	€ 15.3 mn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Different replacement rates of cables

In our central case we assume that all cables need to be replaced every second year. If we redo the calculations with 3, 4 and 5 year-long replacement cycles, we find that the value of the reduction in CO_2-equivalent emissions could be as low as €5.3 million when the replacement cycle is 5 years, see Table 17.

Table 17
Different replacement cycles of cables

	Replacement rates		
Replacement cycle (i.e. how often the cable stock needs to be replaced)	3 years	4 years	5 years
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	€ 8.9 mn.	€ 6.7 mn.	€ 5.3 mn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

Other emission data sources

In our central case, we have used emissions data of producing Lightning cables provided by Apple. The carbon footprint analysis of the charging cables uses Apple's Life Cycle Assessment (LCA) models - the same models used for other Apple product carbon footprint analyses.[91] In the specific case of charging cables, Apple's LCA models rely on industry average data for many of the materials and manufacturing processes, as opposed to measured data at actual manufacturing facilities making these cables. This is a common practice in LCA and provides a reasonable estimate of carbon impact for these products.

As many cables are similar in composition and manufacturing processes, Apple believes these carbon footprints for Apple cables are similar to the carbon footprints of comparable cables. Apple cables do differ in that they do not use PVC (polyvinyl chloride, a plastic material). While this is an important innovation in smarter chemistry, it does not have a material impact on the carbon footprint of these cables.

To examine how sensitive our results are to the choice of emission data, we provide three calculations with other data sources for emissions of cables. The first one is Apple's emission estimate of USB Type-C cables, the second one is the emission estimate of mobile phones cables as reported in Charles River Associates, CRA (2015)[92] and the third one is Risk & Policy Analysts, RPA (2014)[93]

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[91] See https://www.apple.com/environment/.

[92] Charles River Associates, 2015, *Harmonising chargers for mobile tele-phones: Impact assessment of option to achieve the harmonisation of chargers for mobile phones*

[93] Risk & Policy Analysts, 2014, *Study on the Impact of the MoU on Harmonisation of Chargers for Mobile Telephones and to Assess Possible Future Options*, prepared for DG Enterprise and Industry, Ref. Ares(2014)3114849 – 23/09/2014

emission estimate of mobile phone charging blocks and cables. RPA does not have separate estimates for charging blocks and cables, so the calculation using RPA's data point implicitly assumes that both charging cables and charging blocks are reduced.

Table 18
Other emission data sources

Country	USB Type-C	CRA, 2015	RPA, 2014 charging block + cables
CO_2-equivalent emissions per charging cable	0.9 kg	0.66 kg	1.6 kg
Net Present Value of reduction in CO_2-equivalent emissions from reduced annual sales of charging cables in the EU (excl. the UK)	€ 20.0 mn.	€ 14.7 mn.	€ 35.6 mn.

Note: The formula for calculating the Net Present Value (NPV) is: $\sum_{i=1}^{n} Consumer\ value_i/(1+r)^i$, where i denotes the year and r is the social discount rate.

Source: Copenhagen Economics

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