D4.1 Review of current governance regimes and EU initiatives concerning Open Standards and OSS

WP4 Governance and Technologies: Interrelations and Opportunities

TRIGGER

TRends in Global Governance and Europe's Role

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Executive Summary

For more than two decades, the European Commission has promoted the use of open source software (OSS) and open standards by public institutions on the European Union (EU) and member state levels. The creation of technical interoperability between the information and communications technologies (ICT) of different EU countries and institutions has been one important rationale for the promotion of OSS and open standards. More interoperability, the reasoning went, would speed up the creation of the digital single market and lead to more innovation and competition among different ICT providers, thereby fostering economic growth in the Union's member states. The promotion of OSS and open standards is moreover a powerful geopolitical tool. A second important rationale for the EU's policies therefore was to strengthen its position in global technology governance and support its domestic ICT industry by undermining (mostly) US-based proprietary software firms. Now, more than twenty years after the Commission began promoting OSS and open standards, it is time to take stock and assess whether the EU's policies truly are fostering interoperability and making the Union a more powerful actor in global technology governance.

As regards the first policy goal, OSS and open standards can indeed contribute to more interoperability. The relationship between OSS and interoperability is, however, not straightforward. Not all OSS developers prioritize interoperability, which means that governments need to provide incentives for OSS developers to create interoperable solutions. One way for OSS developers to ensure interoperability is by implementing in their products and services application programming interfaces (APIs) that are based on open standards. Policymakers can support such developers by, for example, drafting procurement policies that give preference to open source software that implements open APIs.

The contribution of a standard to interoperability increases with the actual openness of the standard. However, governments face a trade-off between requiring complete openness – which necessitates the free sharing of standard-essential patents (SEPs) – and incentivizing investments in research and development (R&D). Policymakers therefore need to decide to what extent and at what cost they want to promote interoperability through open standards. This decision is complicated by the fact that scientific research has not been able to establish a clear link between the promotion of interoperability and the creation of more innovation and competition in countries' ICT industries. To solve this conundrum, policymakers might consider a multi-stakeholder effort for re-defining fair, reasonable, and non-discriminatory (FRAND) licenses in a way that satisfies both the owners and the implementers of SEPs. Alternatively, policymakers might opt for the promotion of tiered licensing fees that differentiate between patent implementers according to their organizational status and goals (similar to fair use provisions in copyright law). This might allow for the concurrent promotion of R&D and of openness with all its attendant benefits.

As regards geopolitics, the promotion of OSS and open standards can be a powerful tool for states to improve their economic and political positions vis-à-vis their rivals. Thus, the promotion of open standards can strengthen the economies of those countries whose domestic firms are either, on balance, SEP implementers or treat their intellectual property as a factor of production rather than a revenue source. The European Union is home to a number of the world's largest SEP holders, which derive significant revenue from licensing their SEPs. This would make the promotion of open standards seem like a suboptimal policy for the EU. However, there is a second – normative, but ultimately also economic – dimension to promoting open standards and open source software. Since both open standards and OSS support accountability, transparency and democratic participation in policymaking processes, advocating their creation and use undermines those countries that are designing and aggressively promoting closed, intrusive, government-controlled technologies. This, in turn, counteracts global authoritarian tendencies and slows down the spread of privacy-infringing software. It also improves EU-based firms' chances of differentiating themselves by developing open, yet privacy-preserving, technologies and selling them successfully in international markets.

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List of Acronyms

AI = Artificial Intelligence
API = Application Programming Interface
B2B = Business-to-Business
B2C = Business-to-Consumer
CEN = European Committee for Standardization
CENELEC = European Committee for Electrotechnical Standardization
CIA = Central Intelligence Agency
CTI = Informatics Technical Committee
DARQ = Distributed Ledger Technologies, AI, Extended Reality, Quantum Computing
EEE = Embrace, Extend, and Extinguish
EIF = European Interoperability Framework
ERP = Enterprise Resource Planning
ESS = European Standardization System
ETSI = European Telecommunications Standards Institute
EUPL = European Public License
F/OSS = Free / Open Source Software
FRAND = Fair, Reasonable, and Non-Discriminatory
ICT = Information and Communications Technologies
IEC = International Electrotechnical Commission
IEEE = Institute of Electrical and Electronic Engineers
IM = Instant Messenger
IoT = Internet of Things
IP = Intellectual Property
IPR = Intellectual Property Rights
ISO = International Organization for Standardization
ITU = International Telecommunication Union
OECD = Organization for Economic Cooperation and Development
OIN = Open Invention Network
OOXML = Office Open XML
OSOR = Open Source Observatory and Repository for European Public Administrations
OSS = Open Source Software
R&D = Research and Development
SDO = Standard-Development Organization
SEP = Standard-Essential Patent
STEM = Science, Technology, Engineering, Mathematics
UN = United Nations
WIPO = World Intellectual Property Organization
WTO = World Trade Organization
W3C = World Wide Web Consortium

1. Introduction

For the last 25 years, the European Union has promoted the use of free, user-modifiable open source software (OSS) and open standards (where the technical specifications are readily available and usable, having been developed in a transparent process, allowing for input from all). The EU has sought to foster open standards and OSS through a variety of policies, including public procurement requirements for its own and the member states' public administrations, procurement guidance and recommendations, and a variety of other policies.

This report analyzes European policies that seek to foster open standards and open source software, including their goals, feasibility and effectiveness in achieving the stated objectives. We also examine – possibly unintended – consequences for innovation and economic growth, democratic participation and accountability in an age of increasing eGovernment, as well as for transparency and privacy in general. We also consider how open standards and OSS policies are affected (and might in turn be affected by) related policy fields, especially antitrust/competition policy.

We begin in sections 2 and 3 with a brief conceptual clarification of open standards and OSS, respectively, and an examination of the public policy purpose of promoting this type of standard and this type of software. Standards, for instance, generally allow different devices, tools and technologies to interoperate, complement, or substitute for each other, with beneficial knock-on effects including greater accessibility, competition, and innovation (Blind 2004; Blind, Petersen, & Riillo 2017; Bitzer & Schroeder 2006; Bitzer & Schroeder 2007; Ghosh 2007; Zhu & Zhou 2012). We then provide an overview of the EU initiatives fostering open standards adoption and OSS use – and analyze EU policies in comparison with the open standards (and OSS) initiatives of the United States, China, and around the world.

Sections 4 and 5 examine the strategic role of open standards and open source software. In Section 4, we analyze the extent to which open standards can support access to new technologies, lower market entry barriers for firms, increase innovation, and foster competition in technology markets. We then share advice on how the European Union can increase its influence on global technology governance by taking an active role in standard-setting processes. We also describe how dominant proprietary firms might undermine open standards' contribution to interoperability. For open source software, we analyze the extent to which OSS contributes to the creation of a public good and fosters security, sovereignty, innovation, and competition. We then briefly describe the extra precautions that actors with high security requirements (e.g. the military) need to take when deploying open source software.

Section 6 discusses applications of open standards and open source software. In particular, we explain how open standards and open source software support the (further) development of new technologies such as distributed ledger technology / blockchain, artificial intelligence (AI), extended reality, and quantum computing. We then explore how open standards and open source software can be applied together to create more interoperability and foster

increased innovation and competition. We close this section with a caveat, namely that fostering interoperability by supporting open standards and OSS is not enough to guarantee competition in software markets. In some cases, further steps such as data-sharing mandates might be required to keep software markets competitive.

Section 7 lays out the relationship between precaution and innovation, which is complicated by the fact that new technologies bring with them a host of positive and negative side effects that cannot be known before the technologies are actually in use. We then go on to explain how regulatory resilience can help policymakers and the societies they govern to overcome "shocks" caused by the introduction of technological innovations. We conclude section 7 by analyzing how the use of open source software and open standards in public institutions contributes to all dimensions of regulatory resilience and therefore allows societies to introduce new technologies without being utterly unprepared for the profound economic, political, and social changes these technologies might cause.

Section 8 portrays the "global rulers" that influence perceptions and decisions regarding the use of open source software and open standards in public institutions. We examine the interests and strategies of open source and proprietary software companies, software companies' proxies (such as trade associations and foundations), the owners and potential implementers of standard-essential patents (SEPs), and global standard development organizations. In the context of this discussion, we also analyze the diverging interests and distributive issues that have made fair, reasonable, and non-discriminatory (FRAND) licenses so controversial in the technology industry.

Section 9 explains the implications of promoting OSS and open standards for a number of key themes: economic growth, democratic participation, privacy, transparency, and the formulation and enforcement of effective antitrust laws. We carefully analyze how OSS and open standards affect these important policy goals, and under what conditions they can contribute to – rather than distract from – achieving these goals.

In Section 10, the concluding section of the report, we first analyze the consequences of open standards and open source software for the future of global governance. We then examine how the European Union can influence the governance of open standards and OSS globally. Next, we share ten policy recommendations that allow the EU to increase its influence on global technology governance by taking a clear and principled stance regarding the promotion of open source software and open standards and by advocating these principles in the relevant regional and global institutions. To conclude, we examine the seven dimensions of "actorness," an important thread tying together the different parts of the TRIGGER project, and provide our assessment about the level of actorness the EU exhibits in each of those seven dimensions.

2. Promoting (Open) Standards

Standards, in particular open standards, foster interoperability and its various positive externalities. The European Commission has therefore supported the uptake of open standards in government ICT through procurement requirements, guidelines, and recommendations. However, controversies regarding the treatment of standard-essential patents have hindered the emergence of a universal definition of "open" standards and slowed down the adoption of these standards by open source firms.

Certain countries are moreover promoting open standards to further geopolitical aims that may be at odds with European goals and values and to undermine the competitiveness of the EU's ICT industry. Thus, China has long pushed for open standards in order to be able to access European firms' standard-essential patents for free and support its own SEP-implementing companies. Now that China has itself become a major SEP holder, its stance towards open standards is changing. The US, which has many companies that own large SEP portfolios, has never been particularly active in promoting open standards. This enabled the EU to diminish the dominance of American ICT firms by advocating the use of open standards in government ICT on the EU level and in the member states. These examples show that the promotion of open standards has important geopolitical implications that the European Commission needs to carefully consider.

Standards play an important role in allowing different products and technologies to work together, thereby fostering the establishment of a digital single market in the EU. The creation of standards enables many market players to build upon a common technological base layer, which supports interoperability. Interoperability, in turn, ensures that different applications and technologies can work together seamlessly, regardless of the operating system on which they run or the company that manufactured them. This is of great importance in a world in which cross-sector applications and connected devices – such as virtual assistants – have become commonplace. The interoperability enabled by standards moreover has the potential to create several positive externalities, including increased accessibility, lower market access barriers, more market competition, and more innovation. Additionally, the use of open standards, and especially open data formats, in government ICT allows tech-savvy citizens to easily locate, understand, use, and re-use high-value government data such as spending and performance data for essential public services (Open Government Partnership n.d.). This, in turn, contributes to governments' openness, transparency and accountability vis-à-vis the citizenry.

The easier it is to access a standard's specification documents and to actually implement the standard in a product or service, the more widely the standard will be used and the greater its contribution will be to interoperability and its attendant benefits. This is why many industry experts advocate standards that are as "open" as possible. However, there is currently no universally accepted definition of "open" standards, mostly because there is no consensus among industry participants regarding the treatment of standard-essential patents in "open" standards.

For the purposes of this paper, we consider a standard "open" if it fulfills the following criteria:

- The standard was developed in an open, transparent, and collaborative process;

- the standard specification document is freely available; and

- any standard-essential patents are available either royalty-free or under fair, reasonable, and non-discriminatory licenses.

Whether or not to include the FRAND licensing option for standard-essential patents in the final element of this definition has been the subject of considerable controversy for years. Some open source software advocates reject FRAND licenses, often in particular because they are incompatible with open source licenses such as the GNU General Public License v.2 (or later versions), which do not allow for royalty payments based on the number of distributed copies of a certain software program (as usually required under FRAND commitments) (see Association for Competitive Technology n.d.-a; Dolmans 2010; Free Software Foundation Europe 2016; Husovec 2019; Kahin 2011; Ménière & Thumm 2015). We include the option in our initial definition; then, for purposes of policy analysis below, consider separately the costs and benefits of requiring royalty-free licensing of standard-essential patents.[2]

Standards, and in particular open standards, are an important underpinning of a well-functioning digital single market. They foster interoperability, which has the potential to increase accessibility, competition, and innovation. Open standards are therefore an important tool for counteracting the winner-take-all dynamics driven by direct and indirect network effects[3]. This, in turn, ensures that second-movers also have the chance to successfully participate in technology markets.

2.1. Standards Initiatives in the European Union

The promotion of standards has played an important role in the European Union's interoperability strategy since 1993, when the European Commission launched the *Growth, Competitiveness, and Employment Report* (commonly known as the "Delors Paper"). The Delors Paper stressed the importance of standards for interoperability and recommended that all holders of standard-essential patents guarantee "all companies equitable rights to exploit the patents underlying the standard" (Commission of the European Communities 1993, 98).

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[2] As discussed in greater detail in section 8 below, FRAND is a compromise between the preferences of SEP holders and SEP implementers that protects the implementers while still allowing the patent holders to be rewarded for their investment in costly research and development. That said, there are certainly many issues with FRAND licenses, including the potential for patent "hold-out" and patent "hold-up." These issues notwithstanding, the European Union has consistently advocated licensing standard-essential patents under FRAND licenses since the publication of the second European Interoperability Framework in 2010.

[3] Direct network effects occur when an additional user makes a product or service more valuable to existing users. Indirect network effects are market-mediated and occur when the increased availability and decreased price of complementary goods make a product or service more valuable to existing users.

One year later, in 1994, the *Report on Europe and the Global Information Society* (often called "Bangemann Report") was prepared to support the EU's transition to an information society. Like the Delors Paper, the Bangemann Report emphasized the significance of standards for interoperability. Referring specifically to open standards,[4] the Bangemann report raised the expectation that:

> Open "system standards" will play an essential role in European information infrastructures. […] [Telecom] [o]perators, public procurement, and investors should adopt unified open-standards based solutions for the provision and the procurement of information services in order to achieve global interoperability. (Commission of the European Communities 1994, 18)

Over the next 25 years, the European Commission launched several additional initiatives that recognized the role of standards, and particularly open standards, in fostering interoperability. One notable political initiative was the first European Interoperability Framework (EIF), published in 2004. The EIF was a set of guidelines that was meant to support the pan-European delivery of electronic government (eGovernment) services by establishing interoperability principles across various dimensions. The EIF stated that "[t]o attain interoperability in the context of pan-European eGovernment services, guidance needs to focus on open standards" (European Communities 2004, 9). To be defined as open, a standard had to fulfill several criteria, including that the "intellectual property – i.e. patents possibly present – of (parts of) the standard is made irrevocably available on a royalty-free basis" (European Communities 2004, 9). This formulation irked the holders of standard-essential patents, however, who promptly asserted (directly or via interest groups representing them) that the European Commission's definition of open standards would diminish incentives for companies to enter their best innovations into the standardization process, thereby undermining the process itself (Association for Competitive Technology n.d.-a, 7).

In 2010, the European Commission published the second version of the European Interoperability Framework. In the updated guidelines, the definition of open standards – which were now called "open specifications" – had changed. The Commission no longer required that any intellectual property included in a standard needed to be licensed on a royalty-free basis in order for the standard to be considered open. Instead, it stated that licensing SEPs on FRAND terms was also acceptable (European Commission 2010, 26).

In 2017, the European Commission published another update of the EIF (the "New European Interoperability Framework"). In this version, the Commission opted for a definition of open standards that might be viewed as a compromise between the first and second versions of the EIF. Thus, while licensing standard-essential patents on FRAND terms would not preclude a standard from being considered open under the Commission's updated definition, the New EIF

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[4] The authors of the Bangemann report do not define what exactly they mean by open standards.

made it clear that the Commission preferred royalty-free licensing of SEPs (European Commission 2017a, 12).

In parallel to the EIF, the European Commission also published a number of studies in which it laid out how ICT standardization could help move forward the digital single market. These studies detailed the importance of standards and of standard setting for the European Union's future competitiveness. In a document entitled *ICT Standardisation Priorities for the Digital Single Market*, [5] the Commission (2016, 2) pointed out that "[c]ommon standards ensure the interoperability of digital technologies and are the foundation of an effective Digital Single Market." Conversely, "[d]iffering national standards may significantly slow down innovation and put European businesses at a disadvantage vis-à-vis the rest of the world" (European Commission 2016, 2). Referring to the importance of influencing the standard setting process, the Commission (2016, 5) noted: "[S]tronger European leadership in standard setting […] should increase competitiveness and help European innovations better access the global market." The Commission (2016, 6) also recommended that public administrations at the EU and member state levels promote "open standards and platforms where needed." On an official Commission website focusing on open standards, the Commission emphasized that "[b]uilding open ICT systems by making better use of standards in public procurement will improve and prevent the lock-in issue" (European Commission, n.d.-a).

In 2017, in order to decrease the frictions between the holders and implementers of SEPs, the Commission published a communication that set out the EU approach to standard-essential patents. The communication aimed to strike a balance between the interests of SEP holders and implementers by "incentivising the development and inclusion of top technologies in standards, by preserving fair and adequate return for these contributions, and ensuring smooth and wide dissemination of standardised technologies based on fair access conditions" (European Commission 2017b, 2).

2.2 Standards Initiatives Around the World

Governments around the world are promoting the use of standards, particularly in eGovernment services (Wikibooks 2017a). For the most part, governments also promote the use of *open* standards, even though the term does not mean the same thing in all cases. Thus, a number of (former) EU member states – namely the United Kingdom, Denmark, and the Netherlands – have launched open standards initiatives. While the UK and Danish initiatives focus on the use of open standards in eGovernment services, the Dutch initiative is much broader, encouraging the use of open standards across the public sector (Wikibooks 2017a).

Outside of the European Union, many other countries such as Norway, New Zealand, India, Malaysia, Vietnam, Brazil, Chile, Peru, and South Africa promote the use of open standards

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[5] This report uses American spelling everywhere except in direct quotes or when referring to the titles of articles, books, reports, and other documents that use British spelling.

in public administrations. Oftentimes, these government initiatives recommend the use of both open source software and open standards (Wikibooks 2017a), as an approach that promotes the use of both OSS and open standards fosters interoperability and the wide and efficient distribution of technologies.

2.3 Standards Initiatives in China

The European Union is not alone in recognizing the strategic importance of standards and standard setting. China, one of the leading technology powers of today, has also understood that standards are key to its position in the global technology supply chain (Lee and Oh 2008). Accordingly, China has been very active in recent years not only in developing standards for emerging technologies but also in exporting these standards along the "Digital Silk Road" (Arcesati 2019) and in influencing standard setting processes in global standard development organizations (SDOs) (Breznitz and Murphree 2013).

These efforts have several implications for the future competitiveness of the European Union. For one, China has developed unique and exclusionary standards that it has used as an effective trade tool. While many technology standards developed in China, such as TD-SCDMA (for mobile), WAPI (for wireless LAN encryption), and AVD and CBHD (for digital disk players), did not gain traction in the market, China has successfully used the threat of relying on home-grown standards to convince foreign standards alliances to lower their royalty rates (Breznitz and Murphree 2013, 2). This has been a boon for Chinese implementers of standard-essential patents, such as manufacturers of consumer electronics. Standard-essential patent holders, on the other hand, have lost out under such policies.

Companies headquartered in the EU such as Ericsson (Sweden), Nokia (Finland), and Siemens (Germany) are among the world's largest holders of standard-essential patents (IPLytics, 2016). For these companies, which are important contributors to the EU's economy, a policy that systematically lowers the rates that SEP holders can charge for their intellectual property (IP) is not good news. For implementers of standard-essential patents, on the other hand, lower royalty rates are a positive development. Overall, there is a tension between the interests of SEP licensors and licensees and also between the interests of licensors and the societal imperative to diffuse innovations as quickly and efficiently as possible. Resolving this tension hinges critically on defining what FRAND really means (in terms of the licenses being *fair*, *reasonable*, and *non-discriminatory*) in order to reduce inefficiencies associated with the process of implementing standard-essential patents (Ernst 2017, 6).

In addition to pressuring SEP holders to lower their royalty rates, China has used standards and certifications as a tool for coercing foreign firms to open their IP. Rebecca Arcesati, a researcher at the German Mercator Institute for China Studies, writes:

Besides dictating technical specifications, China has cybersecurity regulations in stock that can be used to multiply post-market access barriers for foreign companies at any time and in a targeted manner. With the Cybersecurity Law, a host of foreign businesses have already been forced to comply with an array of sophisticated yet vague standards for cybersecurity review and certification as a precondition for doing business in China. As a result, European firms may be asked to disclose sensitive information and IP (Arcesati 2019)

As Samm Sacks and Manyi Kathy Li of the Center for Strategic and International Studies explain, the Chinese state can use new domestic cybersecurity standards to compel foreign firms to undergo invasive product reviews during which they might have to disclose sensitive IP and source code as part of verification and testing (Sacks and Li 2018). Thus, these standards, which are allegedly meant to ensure that foreign products do not endanger China's cybersecurity, make China an increasingly difficult market for foreign firms and create a competitive advantage for Chinese companies.

China has also increased its influence in global SDOs. This, according to Arcesati, is part of China's state-led plan for technological dominance. Thus, China has been very active in certain committees of important standard development bodies such as the International Telecommunication Union (ITU) and the International Organization for Standardization (ISO). For example, China hosted the first meeting of the SC42 (an ISO technical committee focusing on AI). It also leads the new international research group of the ISO and the International Electrotechnical Commission (IEC) on Internet of Things (IoT) and blockchain standardization.

Being a highly active contributor to standardization processes does not guarantee success, however. As analyst Björn Fägersten (as quoted in Beattie 2019) points out, "[m]ost Chinese proposals for new work items are rejected outright at a very early stage. […] Most proposals are of a very low quality." Moreover, as Tim Büthe and Walter Mattli (2011) point out, even if proposed standards are of a high quality, domestic institutions play a crucial role in determining how successful national industries are at shaping international standards. Thus, influence in international standard-setting processes is due mainly to domestic standard-setters' ability to provide well-timed input and speak with one voice. While China has a centralized political system and the state plays an "expansive role" (Breznitz and Murphree 2013, 2) in standard setting, China's standard-setting institutions are not truly unitary. This means that the relevant Chinese actors do not always speak with a single voice in standard setting processes. In fact, "China is far from a single-minded strategic actor. […] Bureaucratic infighting often undermines Chinese standards, even those which ostensibly present a real technological challenge to the West" (Breznitz and Murphree 2013, 5). According to a standards expert interviewed in China by Dan Breznitz and Michael Murphree, "[d]ifferent ministries are constantly competing for influence and budget. Wars over standards are fought in the bureaucracy over power and fiscal turf" (Anonymous, as quoted in Breznitz and Murphree 2013, 46). Another standards expert

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interviewed by Breznitz and Murphree noted that Chinese national standards efforts were slow because the Standardization Administration of China needed to balance the interests of different ministries. Finding broad compromise was often difficult, according to the interviewee, because different ministries such as the Ministry of Science and Technology and the Ministry of Industry and Information Technology have different favored standards and protocols (Breznitz and Murphree 2013, 46).

According to Fägersten and his co-author Tim Rühlig (2019, 8), "[t]he diversity of interests and the fragmented character of the Chinese party-state mean that the PRC [People's Republic of China] has no interest in adopting the hierarchical European model of standardization." Given this, it remains to be seen how successful China will be in the medium to long term at developing unified positions in order to shape technical standards according to its own priorities and interests.

So far, China has managed to influence one important aspect of the standard setting game by advocating for inexpensive licensing options for standard-essential patents. The reason for China's stance lies in the country's larger geopolitical strategy. Rather than focusing on creating revenues from licensing fees, China aims to increase product sales and spread its technologies to other countries, especially developing countries along the new Silk Road (Arcesati 2019). As Breznitz and Murphree explain, most Chinese firms view intellectual property rights (IPR) as a factor of production rather than a critical source of income:

> The second approach to IP could be called "IPR as a factor of production." Here, IPR is not a direct source of revenue but rather a means to improving products. A way to think about these differences is to think how Apple changed where value is created in the music distribution industry. When Apple released the iPod in 2001, it revolutionized the music industry by turning the prevailing logic on its head. Hitherto IP (songs and content) were expensive - $20 or more for a CD – while music players (the hardware) were increasingly commoditized and cheap. Apple made the hardware expensive, sleek and highly desirable, while charging a nominal price for the IP. This model argues that profit is derived from maximizing the sales of pricey hardware, and hence, prefers to lower the price of all factors of production, IP included. (Breznitz and Murphree 2013, 31)

European (and other) SEP holders for whom patent royalties represent a substantial income stream are threatened by China's push for cheap IP licensing options. As Breznitz and Murphree (2013, 2) point out, the establishment of new norms regarding IP licensing is "the main challenge China poses in standardization."

However, China's stance on IP licensing rates may change, as some Chinese companies have become major SEP holders in recent years (Bharadwaj & Yoshioka-Kobayashi 2018, 184). For example, Chinese firms ZTE, Huawei, and Haier are among the largest owners of SEPs necessary for IoT technologies (Ernst 2017, 8). Similarly, Huawei owns the largest number of SEPs related to 5G technologies, with ZTE and the China Academy of Telecommunications

Technology being the fifth and ninth largest SEP holders, respectively (IPLytics 2019). What is more, the quality of Chinese patents has improved in recent years, meaning that Chinese IP can no longer be dismissed as "junk" (Ernst 2017, 11). Domestically, China has gradually moved "toward a more pro-patent court system" (Ernst 2017, 11). Given that Chinese firms now own a significant number of high-quality SEPs, it is conceivable that more Chinese firms will move towards an "IP as income stream" model in the future and therefore stop advocating free or low-fixed-price licensing of SEPs in international standard development organizations.

In the meantime, however, EU-based owners of standard-essential patents should think about how to react to the Chinese push for lower SEP royalty rates. One potential response is the development and promotion of more *open* standards that can be licensed by implementers on a royalty-free or FRAND basis, a strategy that prioritizes widespread adoption (and, by extension, high sales numbers of hardware and complementary products) over licensing profits. Another option is for the European Union to push back against China's strategy of decreasing the value of IP rights in standard development organizations.

2.4 Standards Initiatives in the United States

The United States has long been an important developer of standards and an active participant in global standardization organizations, but it has been most successful at developing *de facto* standards through market-based processes. In SDOs, the US has typically pushed for the protection of IPR, which is not surprising given that many American companies hold large SEP portfolios. In recent years, however, more and more US companies have started to adopt business models that necessitate giving away some IP for free. Given the increased importance of interoperability in an age of hybrid cloud solutions and cross-vendor workflows, US Federal agencies have also begun to promote the use of open source software and open standards. While this push for OSS and open standards might be aimed chiefly at modernizing public ICT systems, it may also help to counteract the increased tendency towards closed, intrusive, government-controlled technologies.

The rather fragmented domestic standardization landscape in the US (with many competing bodies working on standards for the same industries and technologies) has undermined America's influence in global product standards development (Büthe and Mattli 2011, 165). Thus, despite its economic clout, the US has not always been successful at shaping standards through consensus-driven processes in SDOs.

A different story emerges when looking at market-based standards, however. American technology firms have been very successful at developing de facto standards that end up getting adopted by market participants worldwide. For example, Adobe in 1993 invented the computer file format PDF, which eventually became the de facto standard for scalable and printable documents. Given its widespread uptake and Adobe's continued support for the format, PDF also became a *de jure* ISO standard in 2005. Even earlier, in 1983, Microsoft developed the document

file format DOC, which is supported by virtually all office applications. Despite its nearly global uptake, however, DOC never became a de jure standard. [6]

Given that many American companies own IP that is part of (de facto or de jure) standards, representatives of US companies and standards bodies have typically not supported royalty-free or inexpensive IP licensing options. In contrast to most Chinese companies, a lot of American companies rely on licensing fees as important income streams and as a way to recover prior investments in costly research and development (Breznitz and Murphree 2013, 31). However, it is also worth noting that many companies have begun giving away some of their patents for free while holding on to others. For example, Google is a major creator of and contributor to open source software, but its search engine and a large part of the software behind it are proprietary. Given that these mixed models, in which monetizing IP is only one of several ways to generate revenue, are increasingly common, it is possible that American companies and standards bodies will become more supportive of open standards in the future.

In contrast to most of the private sector, public administrations in the US are already trying to promote standards that are "open" in the sense that they emerge from open, transparent, and collaborative processes. On the federal level, the *Foundations for Evidence-Based Policymaking Act* ("Evidence Act"), which includes the *OPEN Government Data Act*, was signed into law in January 2019. The Evidence Act requires the Office of Management and Budget, the Office of Government Information Services, and the General Services Administration to "develop and maintain an online repository of tools, best practices, and schema standards to facilitate the adoption of open data practices across the Federal Government" (Project Open Data n.d.). Standards play a critical role in fostering such open data practices. As the Evidence Act points out, so-called "voluntary consensus standards," formats, and specifications can be used to support open data. A standard qualifies as a voluntary consensus standard if it was developed through a process that is defined by the following attributes: Openness; balance of interest; due process; an appeals process; and consensus (Project Open Data n.d.). Perhaps not surprisingly given the United States' support for intellectual property protections, the SEPs of a voluntary consensus standard do not have to be given away for free. The standard is, however, "open" in the sense that it was developed in an open, transparent, and collaborative process. As the website of the Federal Chief Information Officer describing the Evidence Act points out, "[s]tandards and specifications developed in processes with the attributes identified above enable data, products, and services to be used by anyone at any time, and spur innovation and growth" (Project Open Data n.d.).

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[6] Microsoft never submitted the specification for the DOC format to a standard development organization in order to have the format certified as a de jure standard. However, in 2008, Microsoft made a concerted – and successful – effort to achieve de jure certification for its Office Open XML (OOXML) formats (including the DOCX format for Word documents) through ISO. The push to make the OOXML formats de jure standards came after the European Commission had published procurement guidelines which recommended that EU public administrations buy only software based on certified, open standards for their eGovernment services. Microsoft's efforts to achieve ISO certification for OOXML were controversial and are discussed in more detail in section 8 below.

On the state level, efforts to promote open standards began much earlier than on the federal level. Thus, the Commonwealth of Massachusetts in 2003 decided to adopt the Open Document Format for Office Applications (ODF), an open standard, as its standard file format. Moreover, the state's IT Division issued a policy that required all state agencies to only buy office productivity applications that featured built-in support for ODF. The state's goal was not to promote ODF specifically, however, but to embrace and support open standards in general (Sliwa 2006). Massachusetts also inspired other states to follow its example. Thus, the state of Minnesota and the state of New York have also conducted research into the use of open standards in public administrations.

3. Promoting Open Source Software

Open source software can be a strategic asset to countries. For one, OSS can help governments to transfer programming knowledge to their populations and support the emergence of homegrown ICT industries. OSS can also decrease the costs of e-government systems and help public institutions reduce vendor dependence and lock-in by making it easy to switch back and forth between different ICT suppliers. Additionally, OSS can help to foster openness, transparency, and accountability in government and therefore potentially decrease political apathy and alienation among populations. Given these various advantages, it is perhaps not surprising that countries around the world – and especially countries that do not possess strong domestic ICT industries – have promoted the use of open source software in e-government systems and in public institutions more generally.

Open source software differs from proprietary software in that it can be freely used, modified, and shared by any interested party. From a user's point of view, this leads to important distinctions between the two types of software: their likely acquisition costs,[7] the types of licenses required to use them, their vulnerabilities, the extent to which the user has control over the software, and the learning effects that accrue from use of the software.

Both open standards and open source software are enablers of interoperability because they allow any interested party to study, (re-)use, and build upon them. Interoperability in turn may lead to more innovation and competition in software markets because it counteracts the direct and indirect network effects that drive the emergence of monopolies in these markets. For governments aiming to create a more dynamic domestic software industry, the prospect of increasing innovation and competition through the use of open source software and open standards is very attractive. Additionally, governments may appreciate the fact that the openness and accessibility of OSS code affords public administrations a measure of control over the software and enables the transfer of high value knowledge to local developers (Rajani, Rekola, and Mielonen 2003).

The use of open source software in public institutions accordingly has the potential to decrease governments' ICT costs and increase their flexibility, freedom, and technological sovereignty. Governments' use of OSS also enables them to quickly scale eGovernment services if needed, audit the source code underlying these services, and hold suppliers accountable in case of problems (Canto e Castro 2019). The citizenry also benefits, as the openness of OSS code allows tech-savvy citizens to find out whether their governments are engaging in illicit data collection or deploying biased algorithms to support important decisions. Thus, the deployment of open source software in government ICT, just like the deployment of open standards, increases governments' openness, transparency, and accountability vis-à-vis their citizens. Open source software can therefore help the EU to further its self-professed values of openness and

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[7] Most open source software is available free of charge. However, this is not always the case.

transparency. The EU can moreover advocate the use of OSS by other governments in order to promote those same values abroad.

Despite the many advantages that governments' use of open source software brings with it, it is important to realize that open source software is not suitable for all domains and scenarios. However, if deployed and managed in a thoughtful manner, open source software can support key economic and political objectives. The discussion in section 5 lays out several relevant aspects that the European Commission should take into account when updating its open source policy.

3.1 Open Source Software Initiatives in the European Union

The European Commission was an early adopter of open source software. Given that not many of the dominant proprietary software companies of the late 1990s hailed from the EU, it is perhaps not surprising that, already in 2000, the Commission drafted a strategy that focused on the internal uptake of OSS by EU institutions and paved the way for the use of the open source Apache Web Server as a recommended solution on UNIX systems[8] (European Commission n.d.-b). After this first foray into promoting OSS, the EU continued to systematically push public institutions on the EU and member state levels to use more OSS in their e-governments systems. According to the EU's own procurement guidelines (European Communities 2004), the use of OSS would provide various benefits, including the creation of greater interoperability and attendant benefits such as reduced switching costs and increased competition in ICT markets.

Three years later, in July 2003, the Commission presented a revised version of the strategy to the Informatics Technical Committee (CTI, with the acronym standing for the French *Comité Technique Informatique*), consisting of the persons who held responsibility in their respective Directorate Generals for information technology. The CTI set a number of clear objectives and made several recommendations. Among other things, the CTI proposed that the EU institutions should use Linux as the server operating system and Apache to power the Europa.eu server. Additionally, the committee recommended that the Commission should use open source software for its blogs and public forums, as doing so would allow members of the Commission and their staff to flexibly change the structure of blogs and public forums when needed.

After having achieved the initial set of goals set by the CTI, the Commission updated its open source strategy in line with both the needs of the EU institutions and the developments in the market for open source software. In 2007, the Commission presented its new strategy for the years 2007 – 2010. In the three years covered by the strategy, a number of important milestones were reached. Among them was the development and approval of the European Public License

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[8] UNIX is a family of multitasking, multiuser computer operating systems that derive from the original AT&T Unix.

(EUPL), a Free/Open Source Software (F/OSS)[9] license that is available in 22 languages and can be used by anyone for software distribution. In parallel to the development of the EUPL, the Commission also introduced various "community platforms supporting OSS development" (European Commission n.d.-b), such as the Open Source Observatory and Repository for European public administrations (OSOR.eu). OSOR is used for sharing source code and best practices. It also contains links to national open source repositories. OSOR thereby supports the re-use of publicly financed OSS code and the generation of EU-wide OSS repositories. Within the Commission itself, the strategy adopted in 2007 led to the uptake of a large number of open source solutions, including several corporate solutions entirely based on OSS. Examples include software for content management, surveys, e-invoicing, and e-ordering (European Commission n.d.-b).

In 2011, the European Commission updated its OSS strategy once again based on an evaluation of the use of OSS within the Commission that was conducted in 2010. The new strategy had several key components, including a commitment to consider OSS solutions alongside proprietary solutions in IT procurement and award contracts on a value-for-money basis. The Commission also committed to promoting the use of products supporting recognized, well-documented standards (European Commission n.d.-b).

The Commission's reference to standards in its OSS strategy shows that there is an important link between standards and open source software. If an open source software program is based on standards, others can easily develop software that interoperates with the program in question because the standard specifications are available to interested parties upon request. It is also potentially lucrative to do so, as the standards that are used in the program in question are likely to be used in other programs as well, guaranteeing interoperability with multiple programs at once. If the standards implemented in the OSS program are *open*, developing software that is interoperable with the program in question is even easier (since standard specifications are freely available and implementation of the standard might be of free of cost). Given that open standards are likely to be used in even more programs than closed standards, it might be more lucrative as well.

3.2 Open Source Software Initiatives Around the World

Given the many potential benefits associated with switching to open source software, especially for countries with weak domestic ICT industries, it is to be expected that the European

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[9] Free/Open Source Software is a term used for software that is both *free* and open source. The "free" part refers to the "essential freedoms" of users defined by the Free Software Foundation. As the Free Software Foundation (2019) explains on its website: "When we call software 'free,' we mean that it respects the users' essential freedoms: the freedom to run it, to study and change it, and to redistribute copies with or without changes. This is a matter of freedom, not price, so think of 'free speech,' not 'free beer.'"

Commission is not the only public institution promoting the use of open source software in governments and public administrations. An analysis of global OSS policies conducted in 2016 by Network World (Gold 2016) shows that countries around the world have laws on the books that either mandate or encourage the use of open source software by public administrations. Political mandates for the use of OSS are most common in South America and Europe, with Bulgaria going as far as to mandate that all software written for the government needs to be F/OSS. A number of countries in East Asia and North America also have open source laws on the books. These kinds of laws are not common in Africa and central Asia, however.

A study conducted in 2010 by Bruno de Moura Borges analyzes the promotion of open source software in member countries of the Organization for Economic Co-operation and Development (OECD), middle powers,[10] and the rest of the world. De Moura Borges finds that most government initiatives promoting OSS adoption happen in the developed world (i.e. the OECD countries), but the middle powers come fairly close. In the poor countries that make up the rest of the world, governments make almost no efforts to increase the use of open source software by public administrations (de Moura Borges 2010, 68).

3.3. Open Source Software Initiatives in China

Like the European Commission, the Chinese government adopted a policy for the use of open source software in public administrations quite early on. In 2002, the Beijing Science and Technology Commission, a part of the Beijing Municipal Government, wrote:

> Beijing Science and Technology Commission has endorsed Linux as China's most important chance to improve its software industry […] [T]he commission would urge Chinese government bodies to consider using Linux with new computer systems, and also encourage private and university software designers to develop Linux and other open source software programs. (As quoted in Lewis 2010a)

Additionally, China's Ministry of Information Industry in September 2002 established an open source alliance to support Linux systems. The establishment of the alliance came after the Ministry of Information Industry had partnered in 2001 with the Chinese Academy of Sciences to encourage the development of the country's software industry, in particular further development of Red Flag Linux [11] (which would receive both ideational and financial support from the

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[10] De Moura Borges (2010, 76) puts the following countries in the "middle powers" category: Argentina, Brazil, China, Egypt, India, Indonesia, Iran, Mexico, Nigeria, Poland, Russia, South Africa, South Korea, Turkey, and Vietnam.

[11] Red Flag Linux is a Linux distribution that was created by the Chinese Academy of Sciences in 1999. After partnering with the Academy of Sciences, the Ministry of Information Industry ordered several government departments to install the Chinese-developed OS, which has been called "China's homegrown answer to Windows" (Muncaster 2014). However, Red Flag Linux ultimately failed to diminish the dominance of Windows in the Chinese market and was discontinued in 2014 (Muncaster 2014).

government). In 2004, the alliance was officially named "Open Source Software Promotion Alliance" and was tasked with encouraging the development of China's OSS industry. The coalition operated under the guidance of the Chinese government and consisted of firms, non-profits, representatives of non-governmental organizations (NGOs), and individuals. In 2009, finally, China became a founding member of "Asian Open Source Software," a consortium that was meant to "advance the adoption and development of open source software among Asian countries" (as quoted in Lewis 2010a).

In more recent years, the Chinese government has invested – and encouraged private investment – in open source solutions in key industries such as semiconductors, IoT, and AI. According to a local executive, the Chinese government's interest in open source technologies is due to their "natural advantages," including the fact that technology firms can develop their own applications on top of the "open and free" fundamental technology standards and commercialize their projects without any fear of patent disputes (Fang, as quoted in Zhao 2018). However, another industry expert claimed that China is ultimately looking to develop its own intellectual property in order to become a key technology power that can compete with the United States and its major SEP holders (Wong, as quoted in Zhao 2018). This seems to fit the narrative of the articles cited in section 2.3 on standards above (Breznitz and Murphree 2013; Ernst 2017). Once a significant number of Chinese companies become major patent holders, China might adapt its strategy for international standard setting. Specifically, it might begin to push for higher payments for licensed IP in global standard development organizations.

3.4. Open Source Software Initiatives in the United States

The US is arguably the leading technology power in the world. It is also home to many proprietary software companies and has therefore never been as active in promoting open source software as the European Union and some emergent technology powers. However, given the increased importance both of fostering interoperability in the context of hybrid clouds and cross-vendor workflows and of promoting open technologies in a world which is in danger of splitting into "open" and "closed" technology blocks, public institutions have taken a number of steps to increase the uptake of OSS by state and federal governments. After the Commonwealth of Massachusetts announced the formal adoption of the Open Document Format for all Commonwealth entities in 2003 and the White House moved its website to Linux servers using Drupal[12] for content management in 2009, the United States officially released an open source policy called the Federal Source Code policy in 2016. As the White House explained:

> The policy, which incorporates feedback received during the public comment period, requires new custom-developed source code developed specifically by or for the Federal

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[12] Drupal is a free and open source content management framework.

Government to be made available for sharing and re-use across all Federal agencies. It also includes a pilot program that will require Federal agencies to release at least a portion of new custom-developed Federal source code to the public and support agencies in going beyond that minimum requirement. (The White House 2016)

Open source advocates criticized the Federal Source Code policy for not going far enough. Open source analyst Bryan Lunduke (2016) wrote that it was disappointing that only a small part of the code developed for the government would be made available to the general public. Lunduke also critiqued the policy's lack of clarity regarding the license under which the code would be released, noting the complete absence of any mention of the GNU General Public License and other "copyleft" licenses.[13] Lunduke also acknowledged, however, that the Federal Source Code policy was "a good first step."

An analysis conducted in 2019 by Jake Rashbass and Mairi Robertson revealed that, in the aggregate, the pilot program requiring US Federal agencies to release newly-developed source code to the public increased neither the creation rate of federal open source projects nor the rate at which users engaged with those projects (Rashbass and Robertson 2019). However, there were a number of standout projects that achieved high levels of user engagement. Thus, the top 0.04% of projects created over 40% of engagement while the long list of remaining projects resulted in little or no user engagement.

Based on a "big data" quantitative analysis of almost 200,000 engagements with over 5,000 different federal open source projects since 2008, and a qualitative analysis of 10 expert interviews, two focus groups involving 12 federal employees, and a literature review, Rashbass and Robertson find that nine factors drive user engagement with public source code. These constitute what the authors call the "DREAM CODE" framework:

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[13] "Copyleft" licenses, notably the GNU General Public License written by the Free Software Foundation, are often described as *viral* because they require derivative works to be distributed under the General Public License (or licenses compatible with the General Public License), too. This means that anybody who uses code licensed under the General Public License in his or her software will also have to release the resulting new software under a "copyleft" license and thereby allow the free usage, modification, and sharing of the new software.

Box 2

SUMMARY OF QUALITATIVE FINDINGS

There are nine characteristics that drive higher levels of user engagement. These constitute the 'DREAM CODE' framework.

Discoverability: **Repositories should be easily discoverable by users**. This will often involve the repository owners taking a 'communication-centered' approach, for example by selecting a user-friendly name for the repository, actively linking to it on their websites, and ensuring it appears in search engine results.

Reusability: **Source code should be complete, self-contained and usable, with minimal recoding required for functional reuse**. This might also entail modularizing the code to separate out the sections that are most reusable.

End user: **Repositories should be developed with specific target populations in mind**. The population needs to have either intrinsic or extrinsic motivation to engage with the code.

Applicability elsewhere: **A repository's contents should provide a wide variety of reuse application opportunities**. They should avoid being too specialized or technical.

Maintenance: **Source code should be regularly maintained after its initial open sourcing**.

Community building: **Repository owners should actively create and engage community around the project**. This might be by targeting a specific community, for example by leveraging passion around a specific issue.

Open origins: **Repositories should be 'written in the open'** – that is, not built as 'closed' software and opened later. Open origins mean the code is developed with the OSS user in mind.

Documentation: **Repositories should have clear documentation and clear descriptions of their contents**. This often includes a mission statement and an outline of the repository's scope.

Explicit licensing: **Repositories should opt for an open source-friendly license** – and be explicit about the terms of that license in its read-me.

Table reproduced from: Rashbass & Robertson (2019, 25).

Based on the DREAM CODE framework, Rashbass and Robertson (2019, 33-46) recommend a number of steps for public administrations to take in order to maximize user engagement with public source code:

- Clearly define the objective of the policy to eliminate confusion that affects how the policy is implemented and therefore negatively impacts user engagement
- Adopt a default requirement for agencies to release all of their code to the public
- Provide additional programmatic support to agencies that allows them to hire community managers that drive user engagement
- Find out, among other things, who constitutes the user base of federally released source code and then target these users in order to create engagement

The steps suggested by the authors can help governments achieve one of the most important objectives of government-driven open source programs: To create more competition and innovation in domestic software markets by making it easy for others to build on federal OSS code, and to allow users to learn from engaging with open source code created by or for public agencies. Without a deliberate strategy for engaging users, governments run the risk of creating open source repositories that are not much more than data dumps that ultimately do not result in more dynamic software markets and a more educated population.

4. The Strategic Role of Open Standards

As mentioned above, open standards play a key role in allowing different products and technologies to work together, and therefore also in the establishment of the digital single market. For one, open standards support interoperability. Interoperability in turn ensures that different applications and technologies can work together seamlessly, regardless of the operating system on which they run or the company that manufactured them. This is crucial, especially where cross-sector applications and connected devices (such as cars, industrial manufacturing equipment, smart household appliances, and smartphones) have become commonplace.

The interoperability enabled by open standards also has several potential positive externalities. These include increased accessibility, lower market access barriers for firms, more market competition, and more innovation.

4.1. Accessibility

If governments use technologies that are based on open standards, this allows all citizens to access eGovernment services and content provided by public administrations. For example, if a government uses a document format based on an open standard for word processing, there will likely be many different office productivity programs – both free and non-free ones – that implement the same standard and that citizens can download in order to open and read government documents (Free Software Foundation Europe n.d.-a). If the same government is using a proprietary program for word processing, in contrast, citizens would have to buy a license to the same proprietary program in order to be able to access government documents. Thus, open standards allow for broad access to eGovernment services, which is important to foster inclusion, fairness, and civic engagement.

Governments themselves also benefit from the accessibility of technologies that are based on open standards. After all, few governments would want their citizens' sensitive data (such as tax data) to be stored in a system to which only one proprietary firm holds the key. If the firm in question goes out of business or decides to no longer maintain the system used by the government, citizens' data may become inaccessible. This is a real problem given the importance of the data. A system based on open standards, on the other hand, will still be accessible in ten, twenty, or even one hundred years given that the standard specification document is freely available and no single firm holds the key to the system.

Companies also benefit from the accessibility provided by open standards. After all, open standards can be implemented by anyone in any technology. This enables even small firms to build new solutions based on open standards.

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4.2. Lower Market Entry Barriers

Given that open standards can be implemented by anyone, promoting them lowers barriers to market access. Small firms can implement open standards and thereby create products that interoperate seamlessly with competing products from larger suppliers that are based on the same standards. This makes it easy for users to switch from a large supplier to a smaller supplier (and back if necessary), injecting a healthy dose of competition into the market.

The modularity that is enabled by open standards also helps small firms enter new markets and compete for government contracts. Given governments' size and importance for the functioning of societies, they require complex, large-scale IT systems. Smaller firms, however, might be strong only in a particular area and might therefore not have the capabilities to build whole systems from the ground up. The use of open standards allows public administrations to match and mix ICT solutions. Therefore, they can procure certain solutions from small local players and others from large multinationals (Wikibooks 2017b). This strategy allows local companies to participate in government procurement processes and therefore helps local ICT industries thrive.

4.3. Competition

Open standards allow small and large companies from different geographies with different technologies to build applications that interoperate and communicate with each other. This makes it easier to exchange and interchange data among different applications. As a result, users can mix and match the technologies they use, meaning that they are no longer caught in a "walled garden" built by a proprietary vendor. For firms, the interoperability between different solutions that is enabled by open standards reduces access barriers to markets, allowing small firms to compete in the same markets as large, entrenched firms. This enhanced competition is possible partly because interoperability helps to counteract the winner-take-all dynamics driven by both direct and indirect network effects. After all, if users can easily switch to the products of another supplier because they can port over all of their information without any issues thanks to the interoperability enabled by open standards, this diminishes the power of entrenched companies to hold on to their customers simply because switching to another supplier's solution is too difficult and likely to cause information loss.

Thus, open standards make it easier for users to switch applications without worrying about losing their data. If a user is no longer happy with the technology she or he initially decided to use, s/he can simply port her / his data to a new solution without issues if the data format follows an open standard. In this scenario, the new application will either be able to use the data as-is or it will be easy to convert the data so that the new application can use it.

4.4. Innovation

Open standards allow many different players to participate in technology markets. Small, medium-sized, and large players can all build technologies that fulfill the same purpose and compete for the same user groups. Competition, in turn, can spur innovation. Users, who have come to expect continuous innovation in technology markets, play an important role in ensuring that firms that find themselves in competitive markets will seek to develop innovative new products or features at a regular rate. Thus, competition in technology markets often focuses on features rather than on price. For example, many customers don't think twice about putting down 700 Euros or more for a new mobile phone because they want to be able to use the latest features, e.g. fast charging, edge-to-edge screens, and triple-lens cameras. Technology companies are happy to oblige (potential) customers' demands for constantly improved features and functionalities. Thus, Apple releases a new and improved version of its popular iPhone every year. While prices for the iPhone are not completely inelastic (Eadicicco 2019), Apple has been posting strong sales numbers for its iPhone XR, which currently retails for 699 Euro (Apple n.d.). Given consumers' willingness to pay high sums for novel, desirable products, features, and functionalities, it is particularly likely that increasing competition through the use of open standards will lead to innovative new technologies.

4.5. Taking an Active Role in Standard Setting Processes

Open standards have the potential to bring many advantages to governments, businesses, and citizens. As described in the preceding parts of this section, open standards make e-government services more accessible for citizens and allow governments to take more control of their ICT infrastructure. They also lower market entry barriers and can increase competition and innovation in ICT markets. While some of these benefits can be realized with closed standards, open standards amplify the advantages that standardization can bring. The reason is that open standards are available for anyone to implement at no or low cost, which means that there will likely be more new technologies based on open standards than on closed standards. Given this, it is vital that the European Union take an active role in standard setting. This means developing a strategy for promoting open standards at the international level.

The Commission's communication on ICT standardization priorities for the digital single market is a step in this direction. National standards bodies, industry, SMEs, non-profit organizations, and public administrations need to work together to create consensus on what the EU's priority areas for standards are and what kinds of standards are needed in these areas. Additionally, the Commission ought to figure out how Europe's standardization organizations can speak with one voice in order to be as effective as possible in promoting the EU's interests in global standard setting bodies.

In 2015, professional services firm Ernst & Young conducted an independent audit of the European standardization system (ESS) on behalf of the European Commission. Based on desk research, targeted interviews, an online survey answered by more than 400 people, and case studies, Ernst & Young found that "the ESS represents a sophisticated framework for the development of standards" that is "facilitating the application of regulatory requirements and ensuring the safety of products" – "achievements [that] have been accompanied and supported by a gradual structuring of and improvement in coordination between the different actors (and in particular, the EC [European Commission] and the ESOs [European Standardization Organizations]), and the processes behind the setup of the standards" (European Commission 2015, 6).

The authors of the report also warn, however, that the "governance and efficiency of the ESS is partly jeopardized by difference of working methods between actors involved (EC, ESOs and NSBs [National Standards Bodies]), and a difficult access to information about standardisation activities by all the stakeholders involved" (European Commission 2015, 7-8). To alleviate these problems, Ernst & Young suggests "[improving] the strategic dimension of the ESS and operation planning by ensuring alignment and consistency between the strategies and planning activities of the various stakeholders (the EC, ESOs and NSBs)" and "[overcoming] the inconsistencies in the working methods of the EC, ESOs and NSBs, and inside different departments or units of the same organisations, which can undermine the efficiency and achievements of the ESS" (European Commission 2015, 9).

4.6. A Caveat

As detailed above, open standards can promote accessibility, lower market entry barriers, competition, and innovation. However, there is a downside to open standards as well. The fact that anybody can implement open standards makes it possible for market participants to apply "embrace, extend, and extinguish" (EEE) tactics that disadvantage competitors. Two concrete examples follow in the next paragraph, but it is important to first describe EEE in abstract terms before illustrating how the process works in practice. When employing EEE tactics, a supplier announces that it supports a particular standard, implements the standard in its products, and begins marketing the products. The supplier then adds in proprietary enhancements to the specification of the standard, alleging that these enhancements are needed to serve certain customer segments or differentiate the product. If the vendor is using EEE tactics, it will enhance the implementation of the standard in such a way that a basic implementation cannot interoperate with the enhanced proprietary implementation. This becomes a real problem if the vendor's products are dominant, as other vendors may then have to modify their implementations of the standard in order to make them compatible with the enhanced, dominant implementation. If the enhanced implementation becomes so widely used that most other implementations support it, this proprietary implementation ends up becoming the de facto standard. Given that the

enhancements contain patented technology, the vendor who developed the enhanced standard has succeeded at hijacking the open standard and making it proprietary (Wikibooks 2017b). Thus, when vendors use EEE tactics, interoperability and competition in the market in question are reduced rather than increased through open standards.

Embrace, extend, and extinguish tactics were often used by Microsoft in the 1990s and early 2000s. For example, Microsoft marginalized AOL Instant Messenger (IM) and established MSN Messenger as the dominant instant messaging client by first embracing AOL's open IM protocol (which enabled MSN users to chat with their friends who used AOL IM) and then extending it with new, proprietary features that AOL was unable to offer or support. Since MSN was provided for free with Internet Explorer, which had ~95% market share at the time, it quickly gained a large number of users. This, in turn, resulted in a huge loss of users for AOL IM due to the fact that AOL IM was no longer compatible with MSN (which meant AOL IM users could no longer chat with their friends who used MSN) and the fact that AOL IM did not offer the same amount of features as MSN (Wilcox 2001).

A more recent example of EEE tactics relates to Google's instant messaging application GChat / Hangouts. When first releasing GChat / Hangouts in 2013, Google embraced Jabber (now called XMPP), an open standard for messaging and presence. Google then expanded on the standard by adding new features such as stickers and drawings. Once GChat / Hangouts had become both widely used and very popular, Google closed off its XMPP gateway, stating that stickers no longer worked with the standard. Given the popularity of GChat / Hangouts, Google's actions for all intents and purposes extinguished XMPP and pushed more people to Google's extended, proprietary version of the standard (Samschooler 2018).

5. The Strategic Role of Open Source Software

The EU has long been aware that open source software can be a strategic asset to countries. Beyond merely allowing countries to foster the emergence of domestic ICT industries, the use of OSS can also help governments in other ways. In a recently published document meant to inform the public about the advantages of open source software, the European Commission's Directorate General of Informatics (DG DIGIT) lists eight distinct benefits of OSS: lower cost, increased flexibility, freedom, endless scalability, sovereignty, security, accountability, and auditability (Canto e Castro 2019). The table below assesses these benefits and their strategic implications for public administrations in more detail.[14]

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[14] It should be noted that these benefits are neither mutually exclusive nor collectively exhaustive. However, I decided to use the list nonetheless, as it reflects the current thinking of DG DIGIT regarding the most important benefits of open source software. DG DIGIT's thinking on emerging technologies often paves the way for policy initiatives, even though DG DIGIT itself is not a policy directorate but rather focuses on providing digital services to other EU institutions.

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Table 1: Benefits and strategic implications of OSS for public administrations

Benefit	Strategic implications of benefit	Caveats related to benefit
Lower cost	OSS that is available for free allows public administrations to lower the initial acquisition costs of software Budget-constrained educational institutions can adopt OSS that is available for free and use it to increase the computer literacy of students	Not all OSS is available for free Even if the software itself is available for free, add-ons, integrations, and other support and maintenance services are typically not free of charge, so total cost of ownership for OSS can be as high as for proprietary software
Increased flexibility	Openness of code enables interoperability, which allows public administrations to choose and switch suppliers as needed, potentially resulting in more competition, more innovation, and lower costs	Not all OSS developers prioritize interoperability; developers therefore need extra incentives to increase the interoperability of their software, Interoperability can also be achieved through the use of open standards, which can be implemented in both OSS and proprietary software
Freedom	Openness of code and modularity of OSS model allow for customizations and changes of software Openness of code prevents "lock-in," potentially resulting in more competition, more innovation, and lower costs	Institutions need to either have the internal capacities (i.e. developers) or pay for external help to be able to customize or change code, which in turn raises the total ownership costs of OSS Not all OSS is interoperable with each other, therefore lock-in might still occur
Endless scalability	A lot of OSS can be freely copied and shared, allowing public administrations to make copies without paying higher licensing fees Modularity of code and large OSS developer community make scaling relatively easy	If no proper maintenance and support agreements are in place for OSS programs, scaling up quickly is difficult and risky OSS that has only been used in small projects may not be robust enough for large projects that scale up quickly
Sovereignty	OSS development is not concentrated in one country or region, meaning that governments can likely purchase software developed domestically OSS code can be studied by anyone, making it hard for hostile governments to insert spyware without being caught fairly quickly	Because OSS development is not concentrated in one country or region, it is sometimes hard to determine who contributed to OSS code: friends or foes? The globally dispersed development process of OSS makes it hard to prevent malicious foreign actors from inserting bad code, which might tempt them to try, even at the risk of being caught quickly

Security	OSS code can be accessed, studied, and modified by anyone, meaning that any malicious code is likely to be detected quickly Since, typically, a lot of different developers work on OSS projects, malicious code is likely to not only be detected but also fixed quickly	The open nature of OSS code allows hackers to spot and take advantage of vulnerabilities, especially if OSS components are not updated regularly It is hard to keep track of different kinds of OSS licenses, which may result in accidental infringement of license terms and cause legal issues
Accountability	Since OSS code can be studied, code that does not meet quality or security standards can be identified and developers of such code can be called out and excluded from future procurement processes if necessary	In many cases, a lot of different developers work on a single OSS program, making it hard to determine who exactly inserted unsafe or substandard code into the program Small OSS firms might go out of business quickly, making it hard to hold them accountable for bad code
Auditability	OSS code can be studied by anyone, meaning that the code can easily be checked for bugs and malware Because of the open nature of OSS code, the code can be checked for flaws and substandard code can be removed	Thanks to contributions by numerous volunteers, many OSS programs change quickly, making it hard to keep track of problems, e.g. buggy code and malware The fast-changing nature of OSS programs also makes it tricky to stay on top of critical updates for OSS components, potentially posing a security risk

Source: Author's own composition

As the table above shows, open source software offers many benefits to governments and public institutions, but there are certain caveats as well (which are briefly examined in the table). Open source software is not suitable for all domains and scenarios, as will be explained in more detail below. However, if deployed and managed in a thoughtful manner, open source software can support key economic and political objectives, some of which are discussed next.

5.1. Creation of a Public Good

DG DIGIT's list does not directly speak to the benefits inherent in the development process of open source software. It is important to note, however, that the OSS development process creates an interesting explanatory challenge for traditional theories of how large social groups collaborate (see Olson 1965). Given that open source software is a non-rival, non-excludable good, programmers should lack the necessary incentives for donating their time and skills to its

development – yet there are thousands of developers who contribute to open source projects. This is why OSS has been called "the impossible public good" (Smith and Kollock 2009).

Many economists, technology scholars, and psychologists have analyzed the individual motivations that underlie the development of open source software (Hars and Ou 2002; Hertel, Niedner and Herrmann 2003; Lakhani and Wolf 2005; Learner and Tirole 2002; Raymond 1999; Weber 2000; Weber 2004). From this research, reputational gains for the programmer have emerged as a selective benefit that is particularly important for motivating contributions to OSS projects (Lerner and Tirole 2002; Raymond 1999).

These findings are relevant for public policymakers in the following sense: Given that reputation, not financial gain, is a key motivator for the OSS community, it is likely that OSS developers will be more willing to build applications that are not interesting for profit-oriented firms, e.g. applications supporting rare languages or features for people with special needs. This is particularly important for public administrations trying to build eGovernment services, which in principle aim to serve all citizens regardless of their language skills or technological abilities.

5.2. Sovereignty and Security

From a political point of view, there are several characteristics of open source software that might be attractive to individuals or governments. Pointing to the US National Security Agency's access codes secretly built into Microsoft's Windows operating system in the 1990s, OSS advocate Richard Stallman (2017) claimed that the only way to avoid unknowingly or unknowably being spied on by proprietary companies was to use open source software.[15] Given the sensitivity of information created and stored by governments, this could potentially be a reason for public administrations to decrease their reliance on proprietary software.

Another, related, reason has to do with the fact that many open source developers live and work in Europe.[16] From a national industrial strategy standpoint, this means that the adoption of open source software will benefit the European Union's ICT industry. As de Moura Borges (2010. 26) pointed out, countries promoting OSS "are able to create an 'industrial policy' without closing the market with protectionist measures or protecting a priori any specific companies." Instead of relying on a few firms, governments adopting OSS enable a wide variety of developer communities to vie for public contracts – "anyone can participate, the standards are open, and there is no product lock-in" (de Moura Borges 2010, 26). Thus, even small local companies have a chance at being awarded lucrative government contracts.

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[15] However, open source software is not immune from bad actors exploiting security weaknesses either – in fact, the openness of the code arguably makes open source software easier to hack than proprietary software. At the same time, if there is a large and active community behind an open source project, vulnerabilities might be detected and fixed more quickly than vulnerabilities in closed source software.

[16] An analysis conducted in 2016 showed that while developers located in the United States made the most contributions to open source repository GitHub, programmers located in Hungary, Germany, and the United Kingdom made the second, third, and fourth largest number of contributions respectively. The fifth largest number of contributions came from China (Hoffa 2016).

From a national security standpoint, purchasing open source software developed by Europeans in the European Union means that EU public administrations have to be less concerned about safety aspects of using the software. Thus, they do not need to worry to the same extent about backdoors in the software that allow foreign powers to spy on them or disable crucial functions of the software at opportune moments (Lewis 2010b).

5.3. Innovation

Even though supporting innovation is an important priority for many policymakers, DG DIGIT's list does not directly speak to the effect of OSS on innovation. There is, however, a large and varied body of economics and management literature that seeks to assess how the emergence and growth of open source software affects innovation and competition in the ICT market. Many authors contend that the open source development model leads to more innovation because of the sharing and rapid improvement of code as well as the modularity inherent in that model (Blind and Edler 2001; Sutor n.d.; von Krogh and von Hippel 2006).

Others claim that the open source development process lacks the incentives necessary for individuals and companies to produce truly innovative work (Evans and Reddy 2003; OECD 2006, 8). In this view, "returns to the innovator result from private goods and efficient regimes of intellectual property protection" (see von Hippel and von Krogh 2009, 2). Since developers of open source software cannot monetize their intellectual property through licensing fees, proponents of this view hold, they do not conduct the hard and time-consuming R&D work required to come up with breakthrough innovations. For this reason, these authors claim (Evans and Reddy 2003, 359; Maurer and Scotchmer 2006, 7), most open source software is imitative rather than innovative. What is more, releasing code under "copyleft" licenses, popular in the open source community, might dampen innovation because proprietary firms might be reluctant to build upon this code (see Hahn 2010, 10).

The contention that OSS developers lack incentives to produce innovative work because it is difficult to monetize open source software might have been valid early on, when OSS was a new concept and its developers were still figuring out how to make money. However, the software industry has changed dramatically since the early 2000s and license fees are no longer the only way to monetize a piece of software. Numerous open source firms have built sustainable businesses by providing service, maintenance, and add-ons rather than charging license fees for their software. In addition, new advertising-based business models have emerged that allow software developers to earn large amounts of money without asking users to buy a software license. Moreover, it has become common for ICT firms (for example, Google and Microsoft) to develop both open source and proprietary software, which means that returns from proprietary products can be used to finance innovative OSS solutions. Finally, it is important to note that increasing amounts of venture capital are flowing into open source firms (Rowley 2017). This

provides open source developers with the necessary capital and freedom to build innovative products without worrying about how to monetize their work (at least initially).

Given the new service- and advertising-based business models that have emerged over the last decade as well as private investors' increased interest   in open source software, it is not surprising that most OSS products are no longer cheap clones or local adaptions of popular proprietary products. Instead, some of the world's leading technology companies such as Alibaba, Amazon, Facebook, Google, Microsoft, and Uber contribute code to open source projects (Hoffa 2017). (Of course, countless smaller technology firms and many individual programmers contribute as well.) Some of the most innovative and widely used technologies developed in recent years, such as the Kubernetes system for deployment, scaling, and management of containerized applications, are open source.

5.4. Competition

The effect of the increase in open source software on competition in the ICT market has been debated among academics and industry experts for more than a decade. Many scholars and advocates believe that the interoperability enabled by open source software leads to more competition because interoperability allows users to easily replace any component of their software stack (Bessen 2004; Henkel and von Hippel 2005; Sutor n.d.).[17]

Others contend that network effects favor incumbents and undermine competition in the ICT market (Casadesus and Ghemawat 2004), no matter how many (open source) alternatives exist. Yet others, building on the concept of *dynamic competition* first introduced by Joseph Schumpeter (1942), claim that strong network effects in a particular software category typically lead to competition *for* the market rather than static price competition *within* the market (Evans 2016; Evans and Reddy 2003; Sidak and Teece 2009). Thus, firms releasing innovative products that resonate with users can displace incumbents.

However, open source software is often aimed at different user groups with different needs than proprietary software: while open source firms tend to target users that have at least basic programming skills, proprietary software is typically aimed at amateur users. This means that multiple software firms with different business models targeting different user groups can co-exist in the same category (Evans and Reddy 2003, 331; Maurer and Scotchmer 2006, 27). Consequently, the promotion of open source software does not always lead to increased competition in the ICT market. It does, however, lead to more choice for different user groups with different needs.

Open source software has become mainstream over the last decade. Many large companies now contribute to open source projects and many firms and public administrations use

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[17] This is only true if the different components of the stack are already open source (and ideally based on open standards) or if interoperability information for the relevant proprietary components of the stack is available at a reasonable price.

OSS for mission-critical applications. Analyzing the market, it is clear that open source software has been particularly successful in business-to-business (B2B) contexts (Nachmany 2019) while proprietary software still dominates in business-to-consumer (B2C) contexts. Thus, OSS has not necessarily succeeded in increasing competition in B2C software markets - for example, Microsoft Office remains the most popular productivity suite for documents, spreadsheets, presentations, and more (Drake and Turner 2019) – but it has certainly changed the competitive dynamics for the better in B2B software markets.

5.5. A Caveat

Open source software might not be the best solution for all domains and all scenarios. Given the open nature of OSS, anybody – including malicious actors – can insert bad code into an OSS program. Thus, OSS might not be the best choice in situations in which security is paramount. For example, the military might be better off using software that is proprietary or even custom-developed (and closed). If OSS is used in domains with high safety requirements, it is vital to ensure that extra security measures are in place. Thus, vendor selection processes must follow high standards, testing procedures must be best in class, and any licensing issues must be fully worked out before deployment. In fact, the best solution in such a scenario likely would be to select a license that allows the user to modify OSS for internal use without having to distribute the modified source code to the public. Under such a license, OSS could be used even in classified or sensitive military systems (or other systems with high safety requirements).

6. Applications of Open Standards and Open Source Software

In its 2016 Communication on ICT standardization priorities for the Digital Single Market, the European Commission (2016, 5) identified five priority areas in which it is particularly important to play an active role in standard setting. These five areas are: 5G communications, cloud computing, the Internet of Things, (big) data technologies, and cybersecurity. The Commission views these areas as "the essential technology building blocks of the Digital Single Market" (European Commission 2016, 5).

Many technologies will benefit from a focused approach to standardization in these areas. In the Commission's own assessment, these technologies include smart energy, advanced manufacturing, intelligent transportation systems, and eHealth (European Commission 2016. 5).

However, there are other areas beyond the ones identified by the Commission as important building blocks for the digital single market that could benefit from a strategic and focused approach to standard setting as well. These areas are **d**istributed ledger technology, **a**rtificial intelligence, extended **r**eality, and **q**uantum computing (DARQ). According to Accenture's *TechVision 2019* report, all four of these technologies are "new technologies to spark a step change, letting businesses reimagine entire industries" (Accenture 2019, 10).

Given DARQ technologies' enormous potential, the European Union should put resources towards shaping standards for these technologies. In doing so, the EU can enhance its influence on global technology governance by enshrining European priorities and values such as openness and transparency in the standards that facilitate the further development and diffusion of these important technologies.

6.1. Open Standards in Distributed Ledger Technology

Distributed ledger technology (DLT)/blockchain shows enormous potential across several sectors, but also faces a significant number of obstacles to its further growth and development. Several of these obstacles could be addressed through standardization efforts in priority areas (RAND n.d.).

For one, standards could increase interoperability between different DLT/blockchain implementations and could thereby lower the risk of ecosystem fragmentation. This would help prevent the emergence of various different, incompatible types of DLTs/blockchains and thereby lower system-wide transaction costs and foster widespread adoption of DLTs/blockchains. Second, and perhaps secondarily, standards could help to introduce consistency to the vocabulary and terminology that is used to discuss DLT/blockchain, which in turn could lead to an improved understanding of the technology and further development of the market. Third, standards addressing the security and resilience of privacy and data governance in

DLT/blockchain could alleviate regulators' safety concerns and increase their confidence in the technology. Fourth, standards could play a significant role in digital identity management and improve end-users' trust in the technology. Fifth, standards could play a role in sectors where provenance tracking is essential. In such sectors, open standards could be used to allow software firms to create common interfaces for enterprise resource planning (ERP) systems and thereby enable blockchain solutions to interoperate with the most common ERP systems from providers such as Microsoft and SAP. This would allow, for example, for seamless tracking of food items from source to table. Thus, software firm Provenance managed to track tuna from fishermen in Indonesia and the Philippines to the plates of consumers in the European Union using mobile, blockchain technology, and smart tagging. Doing so, Provenance was able to verify whether suppliers claiming to sell "socially sustainable" tuna were adhering to the required standards along each step in the supply chain (Provenance 2016). Ensuring that only suppliers who meet high standards along the entire supply chain become certified as socially sustainable suppliers in turn helps workers, consumers, animals, and the environment.

While all of the above advantages can be achieved with closed standards, open standards lower barriers to entry and therefore allow a wide range of actors, including firms of all sizes, public institutions, and non-profits, to implement these standards and build solutions that interoperate with each other. Thus, the adoption of open standards can speed up the widespread use of DLT/blockchain solutions and therefore lead to a quicker realization of the benefits that the pervasive use of DLT/blockchains can bring.

6.2. Open Standards in Artificial Intelligence

Both ISO and the Institute of Electrical and Electronic Engineers (IEEE) are currently working on standards for artificial intelligence. The standards being developed by these two leading bodies focus on improving market efficiency and addressing ethical concerns (Cihon 2019, 2). Thus, ISO is developing some foundational standards that include AI concepts and terminology (Batram 2018). IEEE is working on standards for an ethical personal data artificial intelligence agent. As the IEEE explains, in order to counter the risks of opaque black box machine-to-machine decisions, such a personal AI agent would "negotiate [humans'] individual rights and agency in a system of shared social norms, ethics and human rights that […] helps the individual mitigate ethical implications of data processing" (IEEE Standards Association 2017).

Additionally, standards could help to increase trust in AI systems by addressing issues such as security, privacy, transparency, bias, and system robustness. For example, if a standard development organization drafted a standard for AI-driven e-health applications that enshrined strong privacy and security protections, consumers would know that e-health apps that have officially been certified as compliant with the standard pose little or no threat to users' privacy and security. Consumers might be more willing to use such applications than applications that are not standards-compliant and therefore pose greater risks. Furthermore, standards could aid with

establishing best practices in common AI use cases, for example autonomous driving and transportation. Standards could also help humans navigate the ethical issues that AI raises, for example how we can prevent AI systems from making biased decisions based on the "wrong" data, such as age, ethnicity, or gender. Given the exponential growth of the field of AI, it is to be expected that many more standards will be needed for AI governance. The European Commission should therefore work closely with the European standardization organizations CEN (European Committee for Standardization, with the acronym standing for the French *Comité Européen de Normalisation*), CENELEC (European Committee for Electrotechnical Standardization, with the acronym standing for *Comité Européen de Normalisation Électrotechnique*), and ETSI (European Telecommunications Standards Institute) to promote AI standards that reflect European values such as fairness and transparency.

6.3. Open Standards in Extended Reality

The term "extended reality" (XR) encompasses virtual reality (VR), augmented reality (AR), and augmented virtuality. The technology is promising and can provide new ways for communicating, interacting, and informing. However, uptake of the technology has been slower than hoped for, especially in the consumer category. One reason for the relatively slow uptake of XR in both the consumer and enterprise categories has been ecosystem fragmentation due to a lack of standardization (Armstrong 2018).

Currently, "[t]here are more than eight different VR/AR platforms that developers work on, with no clear leader in sight and no concerted effort towards standardisation" (Malevitis, as quoted in Armstrong 2018). The current lack of standardization not only results in delayed purchasing decisions, but also means that one of the major VR players (such as Google or Samsung) may decide to go it alone, setting the de facto standard and taking advantage of winner-take-all platform dynamics. For the sake of competition and to give second-mover XR companies coming out of the EU a chance at capturing a healthy segment of the market, it would be advantageous for the European Commission to work with CEN, CENELEC, and ETSI to begin promoting the development and adoption of open XR standards in global standards organizations now.

6.4. Open Standards in Quantum Computing

Quantum computing is a technology that is still very much under development. As of now, quantum computers have not been widely adopted. Notwithstanding the technology's early stage of development, IEEE is already actively developing standards for quantum computing. In particular, the organization has started working on a project for the standardization of nomenclature in the field. According to IEEE's Quantum Computing Standards Workgroup, which leads the project, agreeing on a shared vocabulary is a precondition for establishing a real

quantum computing industry and for creating growth and advancement in this promising technological area (Superposition 2017).

Moreover, according to the IEEE, "the emerging industry supplying researchers with quantum-specific lab equipment and subsystems may be ready for formal standards […] in order to assure products will work together once they get into the lab" (IEEE Quantum n.d.). However, not surprisingly given the exploratory nature of most quantum computing research, the IEEE believes it is too early to work on standards for non-technical issues required in mature markets, e.g. standards for the management of international trade or patent positions (IEEE Quantum n.d.). The fact that it is premature to work on these standards now provides the European Union with time to think about the interests and values it would like to promote once work on non-technical standards for quantum computing begins.

6.5. Open Source Software

In principle, any kind of software can be developed through an open source approach and licensed under an open source license. This means that opportunities for applications are unlimited and range from B2C software (such as office productivity suites) to back-end software (such as media server software). A particularly interesting question, however, is how open source software and open standards can interact for the greatest possible benefit.

One example of a successful interaction of OSS and open standards is Kubernetes, an open source cloud computer management software. As industry expert Andy Updegrove explains:

> What's been going on at Kubernetes is this: instead of simply choosing upstream winners and losers, the Kubernetes commercial supporters and development community have defined the areas where Kubernetes needs to interoperate with other products, and then written the APIs (application program interfaces) that developers of others products can code to in order to achieve interoperability. In other words, the Kubernetes developers have written open standards for the interfaces between their open software and the other open and closed software that Kubernetes users may also want to run (Updegrove 2017)

This model, which utilizes both open source software and open standards, is a move away from both the proprietary "walled garden" model as well as the integrated stack model favored by many open source developers. It provides the greatest flexibility possible and thereby minimizes lock-in and the problems that can ensue if a vendor closes its doors or stops supporting a particular technology. The end result of this successful marriage of open source software and open standards is that the Kubernetes ecosystem will potentially become bigger, more dynamic, and more competitive because there are low barriers to entry for developers, it is easy for

integrators to integrate Kubernetes into their package offerings, and users can find a wide selection of products and can easily maintain their platforms (Updegrove 2017).

6.6. A Caveat

Open source software – in particular in combination with open standards – supports interoperability and can therefore lead to more competition and innovation in software markets. However, given the way these markets have developed, promoting the use of OSS by itself may not be enough to guarantee competition and innovation. Software *platforms*, in particular, often exhibit network effects that drive winner-take-all dynamics. Simple people-based, or direct, network effects can be counteracted by the increased interoperability that is fostered by open source software and open standards. However, network effects driven by data are not as easily addressed. For software platforms whose success is partly driven by the collection of user data, insisting that these platforms make their source code open may not be enough to create healthy market competition. Rather than just insisting on open code, it might be necessary to ask these platforms to share their data with smaller firms in order to make sure that these firms can compete. Thus, trying to foster interoperability through political mandates for the use of open source software is a good first step. To create real competition among software platforms, however, it might make sense to mandate the sharing of data between large, dominant firms and nascent competitors. This might enable smaller firms to compete with the largest data-driven platforms such as Amazon, Google, and Facebook.

7. Managing the Tension between Precaution and Innovation

New technologies are an essential driver of economic growth. They can improve goods and services or make their production more efficient. New technologies can even solve – or at least help alleviate – pressing societal problems. However, the introduction of new technologies is not without risks. An important task of the European Commission therefore is to think about the best way to regulate new technologies in order to harness their potential while minimizing the risks they pose to humans, animals, and the environment.

For example, medical technologies have contributed to a rise in overall population health and longevity. At the same time, though, they have also introduced new health risks. Thus, while the introduction of x-ray machines helped medical personnel diagnose a number of diseases that were previously hard to detect and verify, the adverse effects of radiation ended up causing cancer in some people whose exposure to x-rays was too high (oftentimes the medical personnel itself).

The above example illustrates the challenge that the governance of new technologies poses for policymakers: on the one hand, policymakers should welcome and support the development of new technologies in order enable innovators to help solve social problems. On the other hand, policymakers have a mandate to protect citizens from the adverse effects of new technologies. The situation is complicated further by the fact that there are so-called *dual-use* technologies that can serve both peaceful and military aims, which requires an especially cautious approach to managing the risks inherent in these technologies.

7.1. Bridging Precaution and Innovation Through Resilience and Adaptation

To manage these complexities, the European Union has long relied on the so-called *precautionary principle*, detailed in Article 191 of the Treaty on the Functioning of the European Union (EUR-LEX 2016). The precautionary principle, which was first applied in the field of environmental protection, advises risk prevention in the face of scientific uncertainty. Over the years, the scope of the precautionary principle slowly widened to include consumer policy, food, and human, animal, and plant health (EUR-LEX 2016). As the Commission itself wrote in 2000 about the precautionary principle:

> In practice, its scope is much wider [than environmental protection], and specifically where preliminary scientific evaluation indicates that there are reasonable grounds for concern that the potentially dangerous effects on the environment, human, animal, or plant health

may be inconsistent with the high level of protection chosen for the Community. (European Commission 2000, 2)

The precautionary principle is an important guideline in EU policymaking that helps policymakers and regulators keep EU citizens safe. However, questions have arisen in recent years about the scope of the precautionary principle and the relationship between precaution and innovation. In 2011, the European Risk Forum (2011, 4), a Brussels-based think tank, wrote that "[t]he public has become more vocal in recent years in demanding application of the [precautionary principle], seemingly demanding the unattainable goal – zero risk." While zero risk may seem desirable, there is a complex relationship between reducing risk and fostering innovation (and thereby economic growth) that policymakers need to take into account.

By nature, innovative products are new and untested, meaning that their use might have unforeseen negative – and positive – side effects. To be more precise, there are different categories of both risks and opportunities inherent in new technologies that policymakers need to take into account. These range from "known knowns" to "known unknowns" to "unknown unknowns." Thus, policymakers need to consider the known risks and opportunities (known knowns) as well as dangers and potential benefits that are foreseeable but about which nothing specific is known yet (the known unknowns). Most challenging, however, is the fact that certain risks and opportunities associated with new technologies cannot even be foreseen before the technologies are in use. These are the unknown unknowns that make the governance of new technologies an especially tricky subject. In a society that has no tolerance for risk, regulators and citizens might shy away from new technologies because of fears that negative "unknown unknowns" will cause great harm once the technology is in use. Such fearful "wait and see" attitudes will decrease companies' willingness to invest in the development of innovation. Thus, zero-risk societies are in danger of becoming stagnant, potentially resulting in slower economic growth.

In the United States and China, attitudes towards risk are very different than in the EU – though the differences should not be overstated. In the 1960s and '70s, the United States pioneered what later became known as the precautionary principle, according to which "when there are threats of serious or irreversible ... damage, lack of scientific certainty should not be used as reason for stalling action which, on the balance of probabilities, might prevent the damage" (Braithwaite and Drahos 2000, 284).[18] Sweden and West Germany adopted variants of it as one of the guiding principles for environmental regulations as early as 1969 and in the 1980s started to advocate for precautionary approaches at the European and international levels (Löfstedt et al. 2002, esp.382f; Löfstedt 2003, esp.37), but generally European countries and the

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[18] For nuanced discussions of different variants of the principle, see Wiener and Rogers 2002, esp. 320f; Todt and Luján 2014.

EU only started to take a precautionary approach in the 1990s and early 2000s, by which time the notion had come under sustained attack in the United States from industry and libertarian think tanks. This has led some to see a role reversal of the United States adopting or "returning" to a relatively lax regulatory approach just as Europe was adopting precautionary regulations across a range of products and issues (Vogel 2003; 2012). Others have pointed out that many existing and new U.S. regulations are still highly precautionary (Hammitt et al. 2005; Wiener et al. 2010) – albeit in a cultural context that, at least rhetorically, emphasizes and celebrates to a much greater extent the freedom and space for innovators to make, test, and sell new products and services. Arguably, the relatively higher risk tolerance of American citizens, investors, and regulators has allowed once small startups to evolve into some of the largest Internet platforms on the planet. Amazon, Google, and Facebook are examples of U.S. startups that grew rapidly and became huge, powerful companies – with both good and bad implications. Not surprisingly, then, 65 out of the world's 200 largest technology firms by market capitalization are from the United States (Ponciano 2019). Runner-up with 20 firms in the top 200 is China (Ponciano 2019), another country that is known for having taken a laissez-faire approach to the regulation of new technologies that prioritizes economic growth over risk reduction. While market capitalizations are dynamic and say more about the beliefs of investors than about the true health and sustainability of a company and its business model, it remains true that barely any of the most well known and widely used Internet companies were founded in the EU (with Skype and Spotify being two notable exceptions).

Given the European Union's comparatively weak position in the global technology industry, some have suggested that EU regulators should apply the precautionary principle to a much narrower range of cases and counterbalance it with the so-called *innovation principle*. The Commission drafted the innovation principle in 2016 as part of an initiative to establish better regulations. The innovation principle holds that the Commission will take into account innovation when drafting new initiatives (European Commission n.d.-c). The principle is a much-needed counterweight to the precautionary principle that ensures that innovation does not get stifled by an overly developed tendency towards risk aversion. The innovation principle essentially acknowledges that in order to have an innovative society and a growing economy, one needs to accept a certain amount of risk.

However, the innovation principle should not be used to move away from precaution and adopt a regulatory laissez-faire approach that exposes EU citizens as well as animals and the environment to a high amount of risk in order to foster innovation. In recent years, more and more scholars and policymakers have suggested that *resilience* is an important concept for striking a balance between precaution and innovation (Alessi, Benzcur, Campolongi, Cariboni, Manca, Menyhert, and Pagano 2018; Caldera-Sánchez, de Serres, Gori, Hermansen, and Röhn 2016; European Central Bank 2016; European Commission n.d.-d; G20 2017; International Monetary Fund 2016; Sondermann 2016; Sutherland and Hoeller 2016). The resilience perspective acknowledges that not all risks of new technologies can be anticipated. However, instead of

responding to this fact by calling for strict regulations governing the use of new technologies, the resilience perspective advocates the creation of societies that can absorb future shocks stemming from technological innovation.

The OECD (2014, 6) states that investing in three different types of capacities can strengthen resilience: absorptive capacity, adaptive capacity, and transformative capacity. Absorptive capacity refers to the ability of systems to use predetermined coping functions in order to preserve and restore basic structures and essential functions in the face of negative impacts. Adaptive capacity refers to a system's ability to change its structures and functions in order to take advantage of future opportunities and mitigate the impacts of potential negative events. Transformative capacity, finally, refers to the ability to create an entirely new system if the old system ends up becoming untenable.

7.2. Supporting Regulatory Agility through OSS and Open Standards

Regulatory agility is meant to create resilient societies that can handle the changes and shocks stemming from the introduction of new technologies. Open standards and open source software can support regulatory agility by making it easier for regulators to be quick and adaptive – a necessity in today's fast-changing world in which new digital products, services, and business models emerge seemingly every week.

If a "shock" event happens, the use of open standards and open source software contributes to all three dimensions of resilience. When it comes to absorbing the impacts of the shock, open standards and OSS are helpful because they allow governments to make quick changes to important technological applications and infrastructure. OSS gives organizations control over the technology they are using and allows them to adapt it as needed, at least if they have the right in-house resources, most importantly enough highly skilled developers, to mount a fast and effective response.

The use of OSS and open standards also allows governments to adapt in response to shocks or longer-term changes, thus contributing to the second dimension of resilience (adaptive capacity). OSS and open standards enable many different players to be involved in the development of new technologies. This means that there is likely to be more innovation and the pace of change is faster. Given the broad input by many different players, technologies are also likely to be better adapted to real-world needs. Moreover, the use of open source software and open standards enables actors in the relevant technology ecosystem to adopt reusable components, open APIs, and open interfaces into platforms and solutions, potentially increasing the rate at which new products and services come to market. This means that governments may have a larger menu of options to choose from, leading to more competition and therefore to lower prices. As the Linux Foundation puts it:

Building the plumbing upon a common infrastructure enables […] companies and solution providers to differentiate at higher value layers and services, while reducing cost and integration complexity at non-differentiating layers. As a result, […] providers will be empowered to achieve time to market, scale and efficiency much faster than ever before. (The Linux Foundation 2018).

As regards the third dimension of resilience – transformative capacity – OSS and open standards can similarly help to ease the transition to new technological solutions. As in the case of adaptation, the use of open source software and open standards can lead to more innovation at a faster pace. This, in turn, can decrease the time and cost of transformation efforts. An important open question, however, is whether the particular innovation model that is often associated with open standards and open source software – incremental improvements that happen on top of a common, already existing, reusable infrastructure – is suitable for producing the radical innovations required for true technological transformation. On the other hand, one could argue that despite the modularity inherent in the OSS development process, the *breakthrough ideas* required for real transformation might be generated more easily by a global developer community than a (comparatively) small group of employees working for a proprietary software company. To what extent solutions based on OSS and open standards can be truly innovative is therefore a question to which policymakers need to give serious thought.

8. Who Are the Global Rulers?

In their book *The New Global Rulers: The Privatization of Regulation in the World Economy*, Tim Büthe and Walter Mattli (2011) analyze the distribution of power in international private regulatory organizations. Examining who writes the rules, who wins, who loses, and why in three powerful global private regulators, namely the International Accounting Standards Board, the International Organization for Standardization, and the International Electrotechnical Commission, Büthe and Mattli find that private rulemaking by technical specialists is highly politicized. They moreover show that despite the international nature of private rulemaking, domestic institutions play a critical role in affecting patterns of power and influence in private regulatory organizations (Büthe and Mattli 2011). Based on Büthe and Mattli's work, this section of the report analyzes who the global rulers are in the realm of open standards and open source regulations, how power is distributed among them, and how domestic institutions and interests shape OSS and open standards regulations at the international level. For EU decision-makers, it is important to be aware of who exercises power – and how – in order to develop strategies for influencing open source and open standards policies in line with the goals and values of the European Union and its member states.

Mandating the use of open source software and open standards in public institutions has distributional consequences. Government procurement is big business; according to the OECD, public procurement accounts for US$ 9.5 trillion of annual spending in the world economy, the equivalent of 15% of global GDP (OECD, 2017). Given these staggering numbers, it is not surprising that many different organizations try to influence governments' perceptions and decisions regarding open source software and open standards.

Open source developers and organizations representing their interests have strong material incentives for encouraging the use of OSS by public institutions, whereas proprietary software companies and their proxies have a similarly strong commercial rationale for advocating against it. Similarly, the owners of standard-essential patents are likely to have different views about the mandatory use of open standards in government technology than companies that do not hold any SEPs.[19] Hence, government mandates for the use of OSS and open standards are controversial and discussions surrounding such mandates have been politicized in many countries, including in many EU member states and on the EU level itself.

Besides industry players and their proxies (such as trade associations and foundations), other actors, including many middlemen, are involved in the standard-setting process and in discussions about the use of OSS and open standards as well. These actors reside on many different levels ranging from the national to the regional to the supranational level. This multitude

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[19] We are oversimplifying here for the sake of emphasizing the distributional consequences of government mandates for the use of open source software and open standards. The actual business models of the different actors are not as one-dimensional as described here – and, accordingly, their interests are not as straightforward as described here either. A more nuanced discussion of the different actors' business models and interests can be found in sections 8.1 – 8.3 below.

of actors with varying interests, mandates, and resources makes governance in this particular realm of technology rather difficult.

8.1. Open Source Vs. Proprietary Software Companies

Until about ten years ago, there were two kinds of software companies: proprietary companies and open source companies. Proprietary companies had their in-house developers write software that would then be licensed to customers for a fee. Accordingly, customers were not allowed to modify, share, or even view the code of the program for which they had purchased a license. On the positive side, proprietary software was easy to navigate and did not require a high level of technological sophistication, as it came out of the box ready to use. On the other end of the spectrum, open source companies developed software in a collaborative way and allowed users of the software to view the code, modify the program, and share it with others who might need it. Users of OSS often did not have to pay a fee for the software, as the philosophy guiding the open source community centered on getting the software into as many hands as possible without restrictions.

In the 1990s and early 2000s, most open source developers viewed proprietary companies as the enemy. Microsoft, one of the largest proprietary software companies back then, was a particularly popular object of animosity and derision by the OSS community (Bass 2019). This was not surprising given that the company's CEO at the time, Steve Ballmer, said in 2001 that open source was "a cancer that attaches itself in an intellectual property sense to everything it touches" (Ballmer, as quoted in Tung 2016). The aspect of OSS on which the conflict centered was the licensing model underlying the distribution of open source software. The GNU General Public License was especially controversial because of its viral nature, which required anybody using code licensed under the General Public License in his or her software to release the resulting new software under a similar "copyleft" license allowing the free usage, modification, and sharing of the new software. In that sense, the GPL did indeed spread the "no intellectual property rights and no fees" ethos that was so inimical to Microsoft's business model of licensing proprietary software to users at a cost.

Beyond using harsh rhetoric, Microsoft deployed a number of business tactics that were meant to undermine the growth of the collaborative model of software development that was based on open source and open standards. Thus, as described above, Microsoft for a while was famous for using embrace, extend, and extinguish tactics that sometimes ended up ruining competitors that offered products based on open standards. At the same time, Microsoft tried to portray itself as "open" when doing so served its business objectives. In 2008, a few years after the European Commission had recommended the use of open standards in eGovernment services on the EU and member state levels, Microsoft attempted to get its OOXML file format certified as an open standard by ISO. The process was mired in controversy, and while OOXML ended up becoming an ISO-certified open standard (Büthe and Mattli 2011, 57), some open

source activists claimed that the file format was not truly open despite the certification (Free Software Foundation Europe n.d.-b).

Today, the situation is quite different. The technology industry has evolved rapidly, and few companies developing software today fall squarely and exclusively into either the "open" or "proprietary" category. In fact, most large technology companies write proprietary code but also open source a part of their code. Examples of this trend abound: Thus, Google's mobile operating system Android combines an open source base with key proprietary apps and services (Amadeo 2018). Similarly, IBM develops both proprietary and open source software, and recently bought prominent open source company RedHat for US$ 34 billion (Woodie 2018). Even Microsoft, once the "great satan" of open source, joined the Open Invention Network (OIN) recently and offered its entire patent portfolio to OIN members (Woodie 2018). All these examples show that the dividing line between open source and proprietary companies has been blurred in recent years.

What is more, even those companies that develop only open source software have begun to raise some doubts about the strict terms of "copyleft" licenses, which require that any software program re-using "copylefted" code also make available all its code for free without any restrictions. Not all OSS developers are fans of the ideas espoused by GPL creator Richard Stallman, with some saying that it's permissible for developers to use "copylefted" code, yet not release the resulting new software under a "copyleft" license (Bacon 2017). This shift in attitudes likely has to do with the commercialization of open source software. When the OSS development model first emerged, there were barely any commercial open source projects. OSS was community-based, with individual developers from around the world working on projects that they viewed as important (oftentimes with little regard for the commercial viability of these projects). By now, however, there are many commercial open source firms that sell their programs to individuals, other businesses, and even governments. Not surprisingly, commercial firms get nervous when confronted with licensing requirements that force anybody building upon their software to behave in a way that makes it impossible to monetize IP or keep sensitive source code – such as code used in military applications – private. Therefore, commercial open source firms have good reason to release their code under licenses that are non-viral, i.e. that do not require users building upon the code in question to share the resulting new code without any restrictions.

Given how business models and attendant interests have changed over the past decade, it seems likely that software firms are no longer as inclined to wage an "open source versus proprietary" battle in several arenas, including the political arena, as they were in the first decade of the 2000s. In 2010, when the European Commission published the second version of the European Interoperability Framework, the lobbying on both sides was intense. Proprietary firms advocated technology-neutral instead of pro-OSS formulations and demanded that the EIF allow the FRAND licensing of standard-essential patents (de Vriendt 2017). Open source advocates, on the other hand, insisted that the promotion of OSS in the EIF was both justified and important, and that standard-essential patents had to be given away for free if a standard was to qualify as

truly open (Free Software Foundation Europe 2016; Müller 2010). By 2017, however, when the Commission published the third version of the EIF, the advocacy efforts on both sides were less intense – in part because proprietary firms had become more likely to contribute code to open source initiatives and open source firms had become more commercialized (Peter Dröll, personal interview with Nora von Ingersleben-Seip, May 16, 2019).

Thus, the strict dividing line between OSS and proprietary firms has been blurred. In fact, the distinction between open source and proprietary firms might be obsolete since most software companies pursue both open source and proprietary projects. Therefore, it is now harder to predict how industry players might react to the political promotion of open source software. Rather than holding fixed views conditioned by their status as an open source or proprietary player, companies will develop their positions based on a combination of their interests and resources at the time in question.

8.2. Technology Companies' Proxies

When software companies lobby, they do not always do so directly. Instead of – or in addition to – direct lobbying, they rely on proxies such as foundations, trade associations, industry groups, or think tanks to promote their interests. The use of proxies helps companies in a number of ways. First of all, the proxies help to amplify companies' voices by repeating the messages to which the firms themselves seek to call policymakers' attention. Hearing the same messages more often, in turn, makes policymakers more prone to remember the content of the messages and let that content shape their decisions. Second, the proxies provide a cloak of legitimacy to companies' interests. If a trade association with several thousand members promotes a certain position, those advocacy efforts are likely to resonate more with policymakers than the advocacy efforts of a single firm. After all, a trade association in most cases represents more potential voters than a single firm (unless the trade association is small and the firm in question rather large). The legitimacy effect is even more pronounced when the firm in question is foreign and the trade association represents domestic companies and therefore becomes more relevant to policymakers, just like any organization representing domestic interests. For example, if the firm is headquartered in the United States and the trade association represents European companies, its local membership is likely to help the trade association gain access to EU policymakers and convince them of the relevance of the trade association's position. Finally, the non-profit status that is typically granted to foundations, trade associations, and think tanks creates the impression that these organizations are working to further the public interest. This may distract policymakers and opinion leaders (such as journalists) from the fact that the positions these organizations take are often informed by the interests of firms that provide financing to them or support them in various other ways.

Given the many advantages associated with working through proxies, it is not surprising that software companies sponsor a variety of such organizations. A quick Internet search reveals

just how common such sponsorship is. For example, the Free Software Foundation, an organization promoting the use of free and open source software, counts Chinese conglomerate Alibaba Group, Japanese information technology and electronics company NEC, and American software company Red Hat among its sponsors (Rasata 2019). The Linux Foundation, another organization advocating the widespread use of open source software, writes the following about its membership:

> The Linux Foundation and its projects have more than 1,000 corporate members across the Americas, Asia-Pacific, and EMEA, including companies that are leaders in the strategic use of open source. A few include AT&T, Cisco, Fujitsu, Hitachi, Huawei, IBM, Intel, Microsoft, NEC, Oracle, Qualcomm, and Samsung. (The Linux Foundation n.d.)

The fact that Microsoft is a member of an organization promoting the use of open source software shows just how much the technology landscape has changed since the early 2000s. Microsoft might have wanted to join groups advocating the use of open source in the early 2000s in order to get inside information on these groups' positions and strategies and maybe even try to undermine their work. However, it would likely have been difficult for Microsoft to be accepted as member of such a group given its status in the early 2000s as one of the main enemies of the open source community. However, by 2016, Microsoft had become much more supportive of OSS in both its actions and rhetoric and was therefore able to officially join the Linux Foundation as a paying member of the organization (The Linux Foundation 2016).

On the other end of the spectrum, the Business Software Alliance, a trade group that was established by Microsoft in 1988 and has defended intellectual property rights, counts Adobe, Apple, Intel, Salesforce, Siemens, and Symantec among its members (Business Software Alliance n.d.). Similarly, the Association for Competitive Technology, a trade association that has promoted software patents and advocated against forcing companies to give away standard-essential patents for free, lists Apple, AT&T, Intel, Microsoft, and Verizon among its sponsor members (Association for Competitive Technology n.d.-b).

Trade associations, foundations, and think tanks are not simply industry creations that do whatever their donors tell them to do. Rather, they form their own opinions on policy questions and moreover seek to accommodate the varying preferences of their different stakeholders (see e.g. Flöthe 2020). Therefore, it is unlikely that the policy positions and advocacy efforts of any association, foundation, or think tank consistently reflect the interests of one particular company. However, when there is a real conflict between the positions of such an organization and the objectives of a sponsor, financial incentives can be decisive in how that conflict is resolved. A telling example is the argument that recently ensued between the left-leaning US think tank New America Foundation and one of its largest donors, the technology company Google. In 2017, the company criticized the New America Foundation's Open Market initiative multiple times for publishing articles that called for stricter antitrust scrutiny of Google and other tech giants. Instead

of defending Open Market's work as reflecting the foundation's own, legitimate point of view, New America's president fired the lead author of the articles in question (Vogel 2017) and the foundation stopped publishing work that was critical of Google. This incident is evidence of the power that donors can have over the positions and strategies of trade associations, foundations, and think tanks.

8.2. Standard-Essential Patents: Haves Vs. Have-Nots

Policymakers' attempts to promote public institutions' use of open standards, where open standards are defined as standards that are available royalty-free, have been highly controversial. The reason is simple: generally speaking, the holders of standard-essential patents have different views about what constitutes an open standard, and to what extent open standards should be promoted in the first place, than those who do not hold any standard-essential patents. The specific position of any SEP holder and any (potential) SEP implementer on this issue is likely to be determined by several factors, including the entity's business strategy, revenue streams, and internal culture as well as the wider environment in which the entity operates. These nuances notwithstanding, it is fair to say that holders of SEPs are inclined to charge fees to implementers of their patents while companies that do not have SEPs often advocate giving away standard-essential patents for free, arguing that sharing SEPs widely leads to more innovation. In the view of many implementers, for a standard to be truly open, all SEPs contained in that standard need to be given away for free. In the eyes of many patent holders, however, such a model destroys incentives for innovation, as this model makes it impossible to monetize the costly research and development that underlies standard-essential patents.

In order to solve this conflict, and in order to lower transaction costs and foster the wide and efficient distribution of new technologies, standard-development organizations often require patent owners to license their patents on fair, reasonable, and non-discriminatory terms. FRAND licensing of SEPs is meant to, on the one hand, enable the widespread use of standard-essential patents while, on the other hand, allowing patent owners to get rewarded for their intellectual property. In practice, however, FRAND is a contentious concept that is leading to conflicts between SEP holders and implementers time and again. For example, last year, a U.S. court had to decide whether telecommunications company Ericsson's licensing offers to rival HTC were FRAND-compliant (Long 2019). One year earlier, a judge in California had to determine what kind of FRAND rate Ericsson could charge Chinese multinational electronics company TCL Corporation (Long 2018). These examples are but two out of a long list of court cases in which FRAND licenses played a central role.

Controversies about FRAND typically center on one question: What is a fair and reasonable royalty rate to charge for standard-essential patents? While many proposals have been made for how to calculate FRAND licensing fees, there is still no clear definition of a fair and reasonable rate. This leads to disputes between patent owners and patent implementers, which

– for obvious reasons – have conflicting interest in interpreting these terms. The European Commission in 2017 released a study that was meant to "provide a consistent framework for both the interpretation of FRAND commitments and the definition of FRAND royalties" (European Commission n.d.-e). However, as recent court cases show, there are still plenty of disputes regarding the meaning of FRAND commitments and the royalties that may be charged under a FRAND license.

Another problem with FRAND licensing, albeit one that is specific to open source, is that certain open source licenses are not compatible with the core ideas underlying FRAND licensing. According to the Free Software Foundation Europe (2016) and other open source software activists, the licensing of standard essential patents on FRAND terms is incompatible with the requirements of some "copyleft" licenses, including the GNU General Public License v.2 and above. The reason is that the General Public License does not allow any restrictions on the distribution of software, which means that royalty payments based on the number of copies distributed are not permissible. FRAND licenses, however, require per-copy payments. Thus, any open source software program licensed under the General Public License or similar viral "copyleft" licenses that implements an SEP runs into problems if that SEP is governed by a FRAND license. For this reason, the Free Software Foundation is critical of FRAND licensing, stating that standard-essential patents should simply be made available for free so as to allow their implementation in any kind of software, including open source software governed by the General Public License (Free Software Foundation Europe 2016).

Another problem that occurs between the owners and implementers of patents is that of *patent holdup.* As Thomas Cotter, Erik Hovenkamp, and Norman Siebrasse (2019, 1) explain, "[p]atent holdup can arise when circumstances enable a patent owner to extract a larger royalty ex-post than it could have obtained in an arm's length transaction ex ante." Once a company has devoted resources to implementing another company's patented technology in its own technology or product, the holder of the patent is in an excellent position to extract large royalties. The implementing firm, on the other hand, is in a weak position because it has already spent money on developing technologies that depend on the patent in question. The patent holder can therefore extract "unreasonable" royalties. In the context of standard-essential patents, the patent owner can even engage in a *patent ambush.* A patent ambush, according to Paul Belleflamme (2016), is a tactic "whereby a participant to a standard-development process fails to disclose that it holds (or will hold) a patent that is relevant to the standard and only asserts it once the standard is developed."

Belleflamme also points to the possibility of *reverse patent holdup,* also known as *patent holdout*, in which not the patent holder but the implementer has the best bargaining position (for example because the implementer is a monopoly) and ends up paying licensing revenues that are lower – not higher – than the value of the patent.

Implementers that do not hold superior bargaining positions often just ignore patents and patent owners' demands "because the odds of getting caught are small" (Chien 2014, 1). In other

words, companies implement other firms' patents without paying licensing fees and hope that the patent owners either won't notice or won't threaten them with an injunction. According to Colleen V. Chien, many companies, legal practitioners, and policymakers worry about so-called "patent trolls" that help firms practicing patent holdup to extract unreasonable royalties from implementers. However, she points out (Chien 2014, 1) that, "[w]hen large companies systematically 'hold out' on patentees, they have no choice but to work with efficient patent enforcers, or 'trolls.'" The problem is especially pronounced when it comes to SEPs. As Sadao Nagaoka explains:

> [B]ecause the rights holder has made the commitment to licensing its SEP on FRAND terms, the implementer can use the SEP at any time it wishes. Under such circumstances, if there is no threat of injunction from the rights holder, there is little incentive for the implementer to promptly conclude the licensing negotiations. The implementer can even enhance its profit by prolonging the negotiation, since it can strengthen its position and create a stronger financial constraint on the rights holder, whose only revenue source is the licensing revenue. (Nagaoka 2019)

However, patent holdup and patent holdout used to be less of a problem just a few years ago. In 2004, when the first version of the EIF was published, there was not much controversy about the EIF's recommendation that standard-essential patents be licensed for free. The reason was that, at the time, most companies making software and hardware for eGovernment services owned large patent portfolios that included numerous standard-essential patents. These companies therefore were not terribly concerned about the licensing provisions for SEPs recommended in the EIF. After all, if they had to license one of their SEPs to a company, they could simply demand a license to an SEP owned by the other company in return. Such cross-licensing deals made it less urgent to worry about licensing fees and therefore about patent holdup and patent holdout (Peter Dröll, personal interview with Nora von Ingersleben-Seip, 2019).

When the second version of the EIF was published six years later, OSS companies had become serious contenders in the race to sell eGovernment services to public institutions. Since OSS companies did not hold any SEPs, however, the traditional cross-licensing model no longer worked. Therefore, both SEP holders and (potential) SEP implementers began to worry about the terms under which standard-essential patents would be licensed. The European Commission tried to strike a balance between the interests of patentees and patent implementers by stating in the second version of the EIF that SEPs could be licensed under FRAND terms. This did not quite solve the issue, though, as the discussion then began to focus on whether FRAND licensing was compatible with open source in the first place and, if so, what "fair," "reasonable," and "non-discriminatory" actually meant. This discussion, which began with the growth of the open source software industry, is still ongoing, as there is still no consensus on the suitability of FRAND licensing as a tool for balancing the interests of patent owners and patent implementers.

8.3. National Governments

As mentioned above, ownership of SEPs tends to be relatively concentrated in North America and Europe (IPLytics 2016; 2019). Therefore, the U.S. government, as well as the EU Commission and individual European governments, have typically advocated the protection of intellectual property rights through international organizations such as the United Nations (UN), specifically the World Intellectual Property Organization (WIPO), and the World Trade Organization (WTO). Third countries often need to prove that they have stringent regimes for creating and enforcing intellectual property rights in order to be able to sign free trade agreements with the United States and the EU. In addition, both American and European government representatives have promoted the creation and protection of IP rights through standard-development organizations.

As described in section 2.3 above, China was opposed in the past to pushing for strong intellectual property rights because Chinese companies did not own much valuable IP. However, China's role in the technology value chain has changed in recent years, with the country progressing from the "world's workbench" to global technology leader. So far, though, rather than reacting to its newfound technological prowess by advocating for strong IPR protections through international organizations and standard-development bodies, China has engaged in a strategy of de facto standard-setting through the One Belt One Road (OBOR) initiative.

Thanks to OBOR and the huge investments that are part of the project, China has been able to export its homegrown technology standards to countries along the New Silk Road. The export of standards is, in fact, an important goal of OBOR. In a white paper released in March 2015, the Chinese leadership called for improving the technical standards systems in partner countries (Patrick and Feng 2018). However, rather than charging implementers in these countries for standard-essential patents, China is content to give away its IP for free because both the Chinese government and Chinese companies understand the huge market opportunities that come with widely diffusing one's own standards (Arcesati 2019). Thus, it would not be surprising if countries along the New Silk Road soon used mainly technology based on Chinese standards, making it more difficult for EU-based companies to gain a foothold in these countries.

However, while China has been very vocal at proclaiming that its huge investments make it a true partner of the nations along the New Silk Road, Europe has invested similarly large amounts into the countries in question – but without constantly touting itself as a stakeholder in these countries' development (Bartsch and Laudien 2019). Europe's relative modesty regarding its financial engagement on the Eurasian continent is surprising given that it has in many respects been a better partner to these countries than China. This is particularly true with regard to the reliability of Europe's investments. While China originally promised to invest large amounts in OBOR partner countries, its actual financial engagement often lacked behind what was pledged. The EU and its member state Germany, in contrast, have provided ongoing financial flows to many OBOR countries. Given this, Berhard Bartsch and Anika Sina Laudien (2019) suggest that

both Germany and the EU as a whole "can act more confidently as a partner to emerging markets." This includes promoting their own technologies and standards in the countries they support. In Bartsch and Laudien's view:

> The European Union and Germany can present their own institutions, technologies, business models and values as alternatives to China's offerings in the Belt & Road region to a much greater degree than they have in the past. They can also derive greater public and diplomatic benefit from positive examples. (Bartsch and Laudien 2019)

China does have one key advantage when it comes to promoting its native standards, though. That advantage is its huge domestic market. If China establishes certain standards internally, then companies that would like to sell to Chinese customers will have to conform to these standards. Given the size of the market at stake, most firms are likely to adjust their technologies in order to match Chinese requirements.

However, Chinese individuals and households are only attractive targets for foreign consumer-facing companies if they actually buy products and services at a high rate. In other words, domestic consumer spending needs to be high for China to be able to export its standards around the globe.[20] To prompt consumer spending, the state can pursue certain strategies to ensure that citizens have money in their pockets. Since the financial crisis of 2008, the Chinese government has consciously sought to increase domestic consumption through government-led infrastructure investments (*New York Times* 2008), measures to increase household income, reductions of income tax, and improvements to social welfare systems. These measures have helped to spur consumer spending (*South China Morning Post* 2019), putting China in a good position to export its homegrown technology standards around the world.

8.4. Standard Setters

Non-profit standard development organizations such as ISO, IEC, and ITU in many ways serve as middlemen between companies and governments. They seek to ensure (among other things) that new technologies are diffused quickly and widely. At the same time, they aim to protect any intellectual property rights that are included in standards. As discussed at length in section 8.2 above, this is a difficult position to be in, as the diffusion imperative does not always square with patent owners' interest in recouping their R&D costs through patent licensing fees.

SDOs' self-defined purpose is the development of standards that "facilitate communication, measurement, commerce and manufacturing" (CEN-CENELEC n.d.). This sounds like a highly technical task that is far removed from politics (see, e.g., Yates and Murphy 2019). However, in practice, SDOs have to make decisions that have distributive consequences,

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[20] We thank Kevin Kalomeni for making this point (unstructured phone interview with Nora von Ingersleben-Seip, 25 September 2019).

which means that their work does tend to get politicized (Botzem 2012; Büthe and Mattli 2011; Büthe and Witte 2004; De Nardis 2011; Lemley 2007; Perry and Nölke 2017; Richardson and Eberlein 2011; Simcoe 2012; Updegrove 2007; Young 2013). A prime example of such politicization is the standardization process of OOXML, Microsoft's file format for representing spreadsheets, charts, presentations, and word processing documents. Open source activists were opposed to OOXML being declared an open standard by ISO and therefore lobbied against it in the relevant committee meetings. Despite these efforts, OOXML ultimately became an ISO standard. However, there were allegations by OSS companies and their supporters that Microsoft had rigged the process through "ballot-stuffing," i.e. by working with national standards organizations to ensure enough Microsoft supporters were present for the final vote to guarantee a positive outcome (Espiner 2007).

The issue underlying controversial decisions such as ISO's approval of OOXML is the tension between the interests of IP holders and IP implementers. SDOs have to make decisions on how to balance the competing views of these two groups. This is an unenviable task, but also allows SDOs to differentiate themselves as either particularly IPR-friendly or the opposite. The organization's stance can also be reflected in how difficult it is to change its patent policies. As George Willingmyre (2017, 1) points out, "[t]he process [an SDO] employs to revise its patent policy is an aspect of the SDO's competitive posture in the marketplace." Thus, SDOs can portray themselves as either attractive for patent holders or patent implementers, thereby influencing companies' decisions about which of the many competing standards organizations to turn to in order to develop – or receive certification for – a standard.

There are, however, limits to how far SDOs can side with either IP holders or implementers. After all, these organizations are supposed to develop standards that end up succeeding in the market place, which means that they cannot simply ignore the interests of a sizeable portion of market participants. Moreover, many countries have legal requirements that restrict what SDOs can do if they want their standards to be recognized (and possibly mandated, e.g. as part of procurement frameworks) by public authorities.

In the European Union, CEN and CENELEC both have policies that requires disclosure of standard-essential patents at an early stage of the standard-development process:

> Any party participating in the work of CEN and CENELEC is requested, from the outset and at the best of her/his knowledge, to draw attention to any known patent or to any known pending application on patent, either their own or of other organisations that, according to her/his own judgment, may be considered as an essential patent for the deliverable. (CEN – CENELEC 2019)

Similarly, ETSI has a policy that states that "[d]uring the proposal or development of a standard, ETSI members must inform the Director General in a timely fashion if they are aware that they hold any patent that might be essential" (ETSI n.d.). These kinds of rules make it very

difficult for companies to push for their patented technology to become the standard and then pull those patents like a rabbit out of a hat only after the technical specification has been formally adopted as an international standard.

Since the 1980s, private consortia have also begun designing technology standards. According to scholars and industry experts, several factors drive companies' participation in standards consortia: For one, standards organizations are seen by many industry participants as acting too slowly to provide relevant standards in the fast-moving world of technology (Büthe and Witte 2004, 33; Updegrove n.d.; Weiss and Cargill 1992). Moreover, SDOs' democratic decision-making procedures, which enable all parties to participate in standard setting, make some companies feel that their needs are not being directly enough met (Updegrove n.d.). Companies may also participate in standards consortia in order to reduce the costs of standard development by co-operating with firms that conduct substitutable R&D and thereby eliminating wasteful R&D duplication (Baron and Pohlmann 2013). Finally, some companies join private standards consortia to settle potential conflicts of interest before going into formal standardization processes (Baron and Pohlmann 2013) and to form connections with standard-setting peers that can facilitate change requests to ongoing specifications in formal SDOs (Leiponen 2008).

Consortia typically consist of several firms. Governments and research organizations sometimes also participate, but this is rare (Updegrove n.d.). Standards consortia are usually formed to create a standard to address a unique business need (they normally ensure that the products of multiple vendors can interoperate with each other). Thus, their ultimate function is to promote the commercial success of a particular technology-based product or service. As Tim Büthe and Jan-Martin Witte (2004, 32) have pointed out, it is usually not possible for new would-be members to join a consortium once it has been formed, and this lack of openness is one of the aspects of consortia that has frequently been criticized by outside observers.

A standard developed by the technical experts of the participating firms tends to either become the joint property of all members of the consortium or the sole property of the lead firm; the standard might be published and registered as a patent or it might remain unpublished if it is intended solely for the participating firms' own use. Regardless of the exact strategy for protecting the intellectual property of the consortium members, "the objective is to produce a direct, tangible, private benefit for the participating firms" (Büthe and Witte 2004, 32-33.)

Analyzing exactly how common it is for consortia to develop open standards is difficult and may even be impossible, as consortia are private contractual arrangements (often, but not necessarily, joint ventures). This means that there is no such thing as a "register" of consortia in a liberal economic system. What is clear is that some consortia do not seek to patent and license the intellectual property included in the standards they have developed. On the contrary, a consortium may decide that it can best meet its goals by developing a free and open standard. The rationale would be that the openness of the standard will facilitate diffusion, creating market opportunities for the members of the consortium that exceed the value of any projected licensing income. Probably the most famous consortium to produce open standards is the World Wide Web

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Consortium (W3C), the main organization developing web standards. The open standards on which the Internet is based allow anybody to set up a new online service and make it accessible to the rest of the Internet, which is arguably one of the foundations of the Internet's rapid evolution and success. The history and strategy of the W3C notwithstanding, however, private standards consortia typically seek to produce proprietary standards that enable them to monetize members' intellectual property through licensing fees (Büthe and Witte 2004, 32-33).

9. Key Themes

Before we turn to the summary and conclusion, we seek in this section to tease out in some detail the implications of OSS and open standards policy for several key EU policy objectives – fostering innovation and economic growth; increasing transparency; encouraging democratic participation and safeguarding against interference in (or more broadly manipulation of) democratic decision-making; and safeguarding privacy – as well as the implications for an important policy field where member states and the EU Commission itself play a particularly prominent role within Europe and beyond: antitrust/competition law and policy.

9.1. Innovation and Economic Growth

The policy choices of European countries, including jointly at the EU level, with regard to OSS and open standards have consequences for economic growth most clearly by affecting the incentives for innovation and (possibly) opening up economic opportunities. Open standards and open source software contribute to increased innovation in the ICT industry in several ways. The modular nature of OSS makes it possible for companies to develop new software applications that interoperate with existing open source software and OSS-driven devices more quickly, smoothly, and reliably than with proprietary "closed" software for which the source code is – at most – only partially known by stakeholders other than the owner.

The input of a global community of developers moreover enables rapidly generating ideas, which also facilitates the development of new technological products and services. OSS also facilitates adding new functions and features to existing software. Open standards similarly allow developers to build new functions and features based on existing specifications, increasing the rate at which new products and services are introduced to customers. This enables many different players to participate in ICT markets and build on each other's solutions. Interoperability among different devices also allows for technological innovations that were merely science fiction a few decades ago, such as connected cars and smart homes. Who could have imagined in the 1980s that humans would soon be able to receive driving instructions from their cars and order books to their home by talking to a virtual assistant sitting on their living room shelf? These innovations would not be possible without the interoperability that is supported by open source software and open standards. Of course, not every open source software program and not all technologies built upon open standards qualify as "innovative," but there are many that deserve the label. Innovation, in turn, drives economic growth by contributing to greater product diversity, higher product quality, and decreased production costs (Büthe and Cheng 2017).

Promoting the use of open source software and open standards can also help governments foster a strong domestic ICT industry (Weber 2004; de Moura Borges 2010). Since anybody can view, modify, and distribute open source software code, programmers can more readily learn from working with existing OSS programs. This education can already begin in

school, where those interested in coding can try their hands at modifying open source programs. And since OSS typically comes with no acquisition costs, schools and universities can easily download a variety of relevant programs and allow their students to experiment with them. Such experience encourages students to consider careers in computer science and related STEM (Science, Technology, Engineering and Mathematics) fields where most experts foresee severe skills shortages in the years to come and empowers them to take on more high-value-added jobs in the information age.

More broadly speaking, open source software and open standards open up economic opportunities for a greater number of people, thus boosting economic growth. They allow for a more equitable distribution of the knowledge that is necessary for countries to grow and prosper at a time in which digitization is progressing rapidly and most well-paid jobs require at least a basic mastery of a number of technological skills. Closed software and closed standards, on the other hand, keep this knowledge, and the power that comes with it, in the hands of those who already have plenty of it. Entrepreneurs building on freely available open source software and open standards can create successful businesses with very little initial investment, and add value by offering more customized solutions for their own or their customers' products and services. The use of proprietary software and standards, by comparison, requires a larger financial commitment upfront and does not allow for the same opportunities to add value. Thus, the promotion of OSS and open standards allows even countries at lower stages of development to build up successful domestic ICT industries, thus contributing to these countries' economic growth (de Moura Borges 2010). Moreover, open source software and open standards, by virtue of being free or at least relatively cheap, allow anybody with the requisite programming skills to start a company, potentially increasing participation of historically disadvantaged groups in entrepreneurial ventures.

9.2. Democratic Participation

Open source software and open standards have the potential to increase democratic participation. When governments offer online services that are based on open source software and open standards, citizens can take advantage of these services no matter what kinds of ICT solutions they are using at home. For example, if a government publishes documents in an open format such as ODF, citizens can read and edit these documents on a wide range of operating systems without restrictions. Since any modern office productivity suite supports ODF, use of the format enables citizens to open and edit documents, spreadsheets, and presentations on any platform. This means that citizens using Windows, Mac, GNU/Linux, Chrome OS, iOS, Android or any other system can read what the government has written, lowering barriers to democratic participation (Eden 2018). When eGovernment services are based on closed software and closed standards, on the other hand, citizens have to have technologies from the same provider at home – or at least technologies that interoperate with the closed solution the government has deployed.

Otherwise, citizens may not be able to access government documents, submit requests, and so on.

Software (and software-driven devices) often provide solutions that are not equally optimized for all users, as frequently noted especially by people with disabilities, which in the case of eGovernment services excludes part of the population from the use of public services in ways that turns given inequalities into inequities. The basic problem may apply equally to closed and open source solutions,[21] but it is comparatively easy to fix for OSS solutions given the openness of OSS code. Governments that employ talented programmers can even solve this problem internally without relying on the help of commercial software suppliers.

Using OSS and open standards in eGovernment solutions also makes it easier for citizens to monitor what their governments are doing. Thus, technologically savvy residents can check whether the government is collecting data that it is actually not supposed to collect. They can also find out whether there are any biases built into the software – at least more easily than with closed software. Programmers may have consciously or unconsciously imprinted some of their own beliefs and attitudes about the world on their code. This does not necessarily reflect bad intentions. Programmers often simply assume that other users have similar needs as they do (Pienaar n.d.). Since software developers tend to be young males, they might unintentionally discriminate against older, less technologically savvy users, for example. When software code is open, however, other users can spot such biases and ask for them to be fixed (or in some use cases even fix the relevant lines of code themselves).

Additionally, the use of OSS and open standards can allow citizens to participate in the business of governing in a very direct sense. One laudable example of this is the European Union's JoinUp initiative, which – among many other things – facilitated the creation of the Open ePlatform, an open platform for building digital municipal services. Open ePlatform provides an easy and intuitive interface for the people building and maintaining the applications as well as civil servants and citizens working together on particular issues and communicating about these issues. ePlatform is so easy to use that citizens and government employees do not even have to have any programming knowledge in order to build new services and modify existing ones. Instead, everything can be done with mouse clicks. The process is similar to using the website builder Wix, where those eager to make their own website can simply select pre-existing templates, move around pre-existing elements, and fill in empty text boxes to create a site that looks professional but does not require any coding knowledge. However, since Open ePlatform – unlike Wix – is an open source program that is free for anyone to download, modify, and use, those who are technologically savvy can go further: They can actually download the software and then use or modify it in ways that best suits their purposes (Offerman 2016).

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[21] The commercial incentives of proprietary software providers might exacerbate such problems if the user group with customization needs is too small to make finding a solution profitable in expectation.

In voting applications, the use of open source software and open standards can be particularly helpful. In a recent op-ed in the *New York Times*, former head of the U.S. Central Intelligence Agency (CIA) R. James Woolsey and lead technologist of the U.S. National Association of Voting Officials Brian J. Fox (2017) point out: "Open-source software is less vulnerable to hacking than the secret, black-box systems like those being used in polling places now. That's because anyone can see how open-source systems operate." Woolsey and Fox go on to explain that bugs in open source systems can be found and fixed, which, in their opinion, dissuades would-be attackers from striking.

While this is true, it needs to be pointed out that the open nature of OSS code also makes it easier to attack voting software. Bad actors might be deterred from doing so by the fact that anybody with programming knowledge can, in principle, spot their manipulations. However, voting officials should not rely on this deterrence effect alone but should rather make plans for regular software updates and thorough code reviews. The former helps by closing known security loopholes while the latter is needed to ensure that malicious code is indeed detected.

Detection alone is not sufficient; malicious code also must be removed right away, as the example of Equifax, one of the world's largest consumer credit agencies, shows: In 2012, code introduced within the open source Apache Struts project became the attack vector for large-scale data theft. The developer community working on Apache Struts had detected and remedied the issue months before the Equifax breach. However, even though the vulnerability was known, Equifax did not take the necessary steps to locate the vulnerability within its own code base, allowing the issue to persist (Mackey 2018). Equifax's failure to track and update its own code when needed opened the door for attackers to steal sensitive personal and financial information from almost 150 million American and British citizens (Carey 2017).

This example shows that it is crucial for organizations deploying open source software for high stakes operations such as running voting machines or managing consumer credit data to regularly review and patch their code. It also illustrates the difficulty of doing so. After all, large organizations use many different software applications, making it rather challenging to always stay on top of all necessary security updates.

9.3. Transparency

The above benefits extend beyond governmental or public uses of software or algorithmic applications and are fundamentally a function of the transparency that is at the core of open source software and open standards. Open source code and open standard specification documents allow any interested party to review what is happening "inside" a particular technology. This transparency and access is a critical precondition for many of the specific hoped-for benefits of OSS and open standards.[22] For example, transparency can lead to increased democratic

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[22] To be sure transparency is no panacea and the transparency discourse may lead us to overestimate our ability to understand a phenomenon simply because we are able to "see" it [Pachirat; WGI.1b report].

participation. Humans of all ages and backgrounds using all sorts of technological solutions can now easily interact with their governments without ever leaving their home. They can provide information to the government and make requests, e.g. for a new driver's license. Maybe even more importantly, citizens can now be involved in the process of governing by submitting suggestions to open platforms such as the Open ePlatform described in section 9.2 above. This is likely to lead not only to a heightened feeling of connectedness between private individuals and public institutions but also to better governance driven by the wisdom of the crowd. The transparency enabled by open source software and open standards also gives citizens more control over their governments and over corporations, making it less likely that these organizations engage in practices with which the citizenry does not agree.

Counterintuitively, transparency is also an important step in protecting citizens' privacy, as will be discussed in more detail in section 9.4 below. Finally, transparency helps to counteract the winner-take-all dynamics driven by direct and indirect network effects, making it less likely that monopolies emerge. Transparency also allows competition regulators to gather evidence against companies who they suspect of having abused their dominant position. The impact of transparency on antitrust will be discussed in section 9.5 below.

9.4. Privacy

Thanks to the transparency that is at the core of open source software and open standards, citizens can, at least in principle, more easily find out whether the government or private actors are collecting personal information about them without authorization. Thus, open source software and open standards reduce the likelihood that governments and companies collect or share data without permission. They allow citizens to check if secret data extraction is taking place – and if so, what is being done with the data.

A site about the GNU Operating System sponsored by the Free Software Foundation (2020) goes as far as to claim that proprietary software can never be safely used by those who are concerned about their privacy. The article lists several considerations meant to support that claim.

For one, because the code of proprietary software is closed, companies may claim to respect their users' privacy but use the opaqueness of their code as a shield for collecting personal data without authorization anyway. Second, even if companies explicitly state in their licensing terms that they collect and share with third parties only aggregate, non-personally identifiable information, those policies could change. Moreover, anonymized data can often be re-identified and attributed to individuals. Finally, sensitive data collected by companies could be

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Moreover, boundless access to the most detailed information might not so much enhance transparency but create or exacerbate the information overload problem of the "perfect chronicler" (Schneider 1987) (a problem that is only partly solvable through big data analytics). Our point here merely is that foreclosing access to information is bound to reduce transparency.

stolen in data breaches (as was the case in the Equifax example above) or taken by subpoena. Thus, the Free Software Foundation takes the (arguably quite extreme) position that companies ought not to collect data about their users at all. Users can only be sure that no data is being collected, however, if the code of the software in question is open. Of course, the same applies to software used by the government.

Governments eager to help protect the privacy of their citizens can incentivize companies to develop open source software and implement open standards in their products. One way of doing so is to formulate procurement policies that make the use of open source code and open standards a precondition for being able to sell ICT to the government. Given the huge procurement budgets of public institutions, companies are unlikely to forego the opportunity to win lucrative government contracts by sticking to the use of closed source code and closed standards.

However, a broad procurement policy decreeing that all ICT sold to the government has to be based on open source code and open standards might go too far, as there may be areas of governance in which it makes more sense to deploy proprietary software. Thus, procurement policies need to be appropriately narrow and nuanced.

9.5. Antitrust

Network effects are "the key [driver] behind the success of many software-based companies" (Hariharan 2016, 4). Network effects create winner-take-all dynamics, which becomes a real problem when software is not open (or at least interoperable with the software of many other vendors).

Direct network effects, which occur when an additional user makes a product or service more valuable to existing users (Church, Gandal, and Krause 2002, 1; Farrell and Saloner 1985, 70-71; Hariharan 2016, 3; Katz and Shapiro 1985, 424), prompt people to use the same software their colleagues, family, and friends are using (Liebowitz and Margolis, 1994, 133). After all, if everybody uses the same software, there are no interoperability issues. The lack of interoperability issues means that data can be exchanged among different users without any problems.

Indirect network effects, on the other hand, occur when complementary goods make a certain product or service more valuable to its users (Church, Gandal, and Krause 2002, 1; Clements 2004, 633). Thus, people are likely to buy software for which many apps or extensions are available – which usually is the case for the most popular software with the highest user numbers. Given that these apps and extensions were specifically written for the software platform in question, they work seamlessly with it. Other apps and extensions that were built for different platforms might not work as well (if at all). Therefore, software that is already popular becomes even more popular thanks to the availability of complementary goods.

Both direct and indirect network effects can be counteracted with the help of open source software and open standards. After all, if the code of a specific, popular software program is open, developers can write software that interoperates with the program in question. This means they can develop both complements and substitutes for the program in question. Developers have incentives to do both. After all, complements (such as plug-ins or browser extensions) for a popular program are likely to also be popular. It also makes sense for developers to release new programs that copy – and potentially enhance – the features and functionalities of the existing popular program given that, once a particular program has gained traction, this can be seen as proof that users view the features and functionalities of the program as useful. Since the existing popular program is open, the new program can be designed in a way that facilitates the transfer of data between the old and the new program. This makes it easy for users to switch to the new program and therefore counteracts the lock-in that is caused by problems with data transfer between different programs. Once a large enough variety of substitutes and complements for the popular program is available, users can transfer their own data and exchange data with others without issue, diminishing the incentive to use only the popular software. The end result of this dynamic is increased competition in software markets.

Open standards are particularly helpful in counteracting both direct and indirect network effects. If a popular software program is based on open standards, companies wanting to make complementary products can do so by implementing the standard. Firms making software programs that compete with the popular program, too, can implement the standard in their programs. The complementary products made for the popular software program will then also work with the new software programs written by the competitors. The complements therefore not only make the popular program even more popular but also serve to make the new program more attractive. Since the standard specification documents for open standards are freely available and there are many companies implementing popular open standards in their products, it is both easy and sensible from a business perspective to make products, be it complements or substitutes, which interoperate with already existing popular programs. Once a wide variety of products that interoperate with a popular program are available, users again face no issues with data exchange and can freely decide which products they would like to use. Open source software and open standards therefore have the potential to counteract the winner-take-all dynamics driven by network effects and make it less likely that one company becomes dominant.

It also needs to be noted, however, that this potential is not always fulfilled. Even when it is theoretically possible to switch from one program to another without issue, individuals, companies, and governments do not always do so because of path dependence (Arthur 1989). Since it is costly to reverse integrations within existing ICT infrastructures and to learn the ins and outs of new software programs, individuals, companies, and governments often stick with older or less suitable programs in order to avoid those costs.

As described above, open source software and open standards can minimize the likelihood that antitrust issues driven by monopolistic market structures occur in the first place.

They can also help once regulators have a suspicion that anticompetitive conduct has occurred. Algorithms are tools that allow companies to engage in monopolistic practices (Schrepel 2017). For example, online retailers that offer both their own products and the products of independent sellers may use their algorithms to display their own products more prominently than those of sellers offering competing products. The European Commission accused Google of a similar abuse of dominance and eventually the European Court of Justice found the company guilty (European Commission 2017c). Google had placed its own comparison-shopping service, Google Shopping, at the top of search results while demoting competitors' comparison-shopping services in the results (Kathuria 2019, 90). While the European Commission (2017c) did not examine Google's actual algorithms to gather evidence in the case, open source code could in theory help regulators to discover such anticompetitive biases in companies' algorithms. Thus, software programmers working for the Commission could review the source code of companies that might be engaging in anticompetitive conduct in order to establish whether the code contains algorithms favoring the company's own search results or products. Open source code can therefore help regulators to make the case that a certain company has indeed abused its dominant market position.

The extent to which open source software can help prevent the emergence of monopolies and the abuse of dominant positions is, however, limited. Data are nowadays a critical source of competitive power (Graef, Husovec, and Purtova 2018, 1391; Graef and Prüfer 2018; Kathuria 2019, 89; Mayer-Schönberger and Ramge 2018). Even if companies share their algorithms, they might have large advantages vis-à-vis competitors thanks to the data they have amassed. Data network effects drive winner-take-all dynamics just like direct and indirect network effects do. This problem cannot be remedied by simply asking companies to open source their code or base their technologies on open standards. Under certain circumstances, when companies are abusing a dominant position created by the ownership and analysis of data, competition enforcers might therefore require the companies in question to share their data with competitors (Graef, Husovec, and Purtova 2018, 1391; Graef and Prüfer 2018; Mayer-Schönberger and Ramge 2018).

10. Conclusion

The European Union has been promoting open source software and open standards for a quarter of a century. For open standards, the goal of this policy has been to foster widespread uptake of any standard implicitly or explicitly adopted by the EU by making its standard-essential patents (SEPs) available for free, resulting in greater interoperability and, in turn, greater accessibility, competition, and innovation.

For open source software, a key goal of EU policies promoting OSS similarly was interoperability (and ultimately fostering accessibility, competition, and innovation), to which OSS can contribute because its source code is available to be viewed, modified, and shared by anybody. However, interoperability does not come about automatically, as open source developers naturally focus first on making the best possible product with the most useful features, not on maximizing interoperability as such (Sartorio 2008). To achieve the EU's policy objectives, OSS developers need to consciously build interoperability into the software. This can be achieved, for example, by defining the areas in which the software program in question needs to interoperate with other products and then writing application programming interfaces (APIs) based on open standards that developers of other products can code to in order to achieve interoperability (Updegrove 2017). Public policymakers need to incentivize interoperability, e.g., through public procurement policies that reward those who develop open source software that ensures interoperability through APIs. Promoting OSS also matches the EU's self-professed values of openness and transparency because anybody can view and modify OSS code.

The EU's promotion of standards began with the *Growth, Competitiveness, and Employment Report* (widely known as "Delors Paper"), which was published in 1993 and stressed the importance of standards for interoperability among different information and communications technologies (ICT). One year later, in 1994, the *Report on Europe and the Global Information Society* (often called "Bangemann Report") raised the expectation that open standards would play an important role in Europe's information infrastructures and encouraged governments to use public procurement as a tool to foster the adoption of open standards and thereby support global interoperability. The Bangemann report did not, however, define what an "open" standard was, leaving room for different interpretations that suited different stakeholders' goals. This changed in 2004, when the European Commission published the first European Interoperability Framework (EIF). The EIF advised public institutions on both the EU and member state levels to procure eGovernment solutions based on open source software and open standards, and made it clear that a standard was only "open" if all of its SEPs were available for free. This definition caused friction between the European Commission and SEP holders. In the second and third versions of the EIF (published in 2010 and 2017, respectively), the definition of an open standard was changed such that a standard would still count as "open" if its SEPs were licensed on fair, reasonable, and non-discriminatory (FRAND) terms, irritating open source and open standards advocates. The Commission had also recommended in its 2016 report on *ICT Standardisation*

Priorities for the Digital Single Market that public institutions on the EU and member state levels promote open standards and platforms to speed up progress towards the digital single market.

Internally, the Commission has made great strides in adopting ICT solutions based on OSS and open standards. It has also played an important role in promoting open standards and open source software through its engagement with standard development organizations and its support of EU-wide open source repositories, respectively.

Beyond merely *promoting* open standards, the EU can actively *shape* standards in international fora to spread European values such as openness and transparency. Doing so will contribute to the EU's credibility in this domain and increase the EU's influence on global technology governance.

However, as of this writing, it remains controversial whether a standard is truly "open" if its SEPs are licensed on FRAND terms and what "fair, reasonable, and non-discriminatory" licensing actually encompasses. Resolving these challenging issues could lead to the wider uptake of open standards and therefore to more interoperability among different ICT solutions (and attendant benefits such as increased competition, innovation, and economic growth).

10.1 Open Source Software, Open Standards, and the Future of Global Governance

The promotion of open source software and open standards has the potential to shape the future as a form of global technology governance that fosters values such as openness, transparency, and accountability. As described in sections 9.2 – 9.4 above, the openness that is at the core of open source software and open standards gives citizens the opportunity to interact with their government more frequently and more easily than in the past. It also enables citizens to have more control over the activities of their government. If governments are collecting data they are not supposed to collect or if they deploy biased algorithms to make decisions that have distributive consequences (such as allocating welfare payments), tech-savvy citizens can spot such problems when examining the source code of the software that the government is using. Once such problematic activities or biases come to light, citizens can hold their governments accountable and demand changes to the practices in question. In this way, OSS and open standards also contribute to safeguarding citizens' privacy. After all, the use of OSS and open standards in public institutions makes it much more difficult for governments to conceal activities that violate the citizenry's right to privacy (such as the illicit collection and analysis of citizens' data). Therefore, if the European Union wants to foster openness, transparency, and accountability in other countries, the promotion of open source software and open standards on a global level (e.g. through international trade and investment agreements) is one tool it can deploy for doing so.

Beyond aiming to foster openness, transparency, and accountability, the movement for OSS and open standards arose out of very specific ideas that centered on the way in which new technologies could be developed most efficiently: by large, dispersed crowds collaborating openly

rather than by small, centralized groups laboring in secret. The underlying rationale is that transparency and decentralization in the development process lead to a world in which technology is widely shared and consistently improved. Open, continuous, and voluntary collaboration among many programmers is supposed to lead to more competition among commercial interests and greater innovation by allowing small firms and even individuals to participate in global technology development and build on each other's work.

Of course, this model has consequences for the creation and protection of intellectual property. In a world in which source code, technical specifications, and even standard-essential patents are given away for free (which is the world that most organizations advocating the increased use of open source software and open standards are propagating), business models that rely on the monetization of IP are no longer relevant. Firms instead will have to come up with other ways to make money, e.g., by selling maintenance and support services or choosing "freemium" models in which the basic versions of the technology are available for free, but more advanced and/or customized versions come with a price tag.

When promoting open source software and the "narrow" version of open standards (under which SEPs need to be given away for free rather than under FRAND licenses), the EU is creating incentives for technology firms to treat intellectual property as a factor of production rather than a direct source of revenue. This means that firms will have to view IP as a means for improving their products rather than as the product itself. There are certainly firms that have enjoyed great success with this model (for example, open source software firm RedHat, which was acquired by IBM for a whopping US$ 34 billion in 2019). However, from a public policy and public macroeconomics point of view, the fact that private firms that treat IP as a factor of production have been acquired for high sums is not a relevant metric of success. After all, an acquirer might be interested only in the assets of the firm it has bought and therefore ditch the acquisition target's business model as soon as the deal is completed. Thus, such acquisitions cannot necessarily be viewed as proof that the acquired firms had a scalable and sustainable business model. In fact, from a macroeconomic perspective, encouraging companies to treat IP merely as a factor of production rather than a revenue source might have negative consequences. Such a policy might, for example, result in lower investments in R&D by software developers. It might also incentivize firms that implement standard-essential patents to pervert the ideas behind open standards by engaging in embrace, extend, and extinguish tactics. In such a situation, a dominant implementing firm hijacks a popular open standard by building its own proprietary extensions to the standard, creating a de-facto new standard that is proprietary and therefore undermines – rather than supports – interoperability. From the standpoint of geopolitical strategy, this becomes especially problematic when the developer of the open standard is a company headquartered in the EU whereas the implementer is a company headquartered outside the EU.

Promoting open standards and open source software has both benefits and costs. The costs consist of potentially undermining incentives for R&D, with attendant negative effects on innovation, and pushing European companies to make their intellectual property available for free

while companies from other geographies might not have to do the same and might even appropriate the value from European IP without providing any value to EU-based firms in return. On the other hand, the benefits from supporting open source software and open standards through procurement policies and other policy tools are clear and significant. The increased use of OSS and open standards creates a number of advantages: lower prices for eGovernment services and more control over the relevant software; the potential to spur more competition and therefore more innovation and economic growth in European ICT markets; the ability to spot and persecute anticompetitive behavior more easily; a higher level of openness, transparency, and accountability in governance processes; and – importantly – increased democratic participation. Given this long list of benefits, EU decision-makers have good reasons to continue supporting the uptake of OSS and open standards on the EU and member state levels. At the same time, given the costs of these policies, the promotion of OSS and open standards should never turn into a dogma that is blindly followed in all domains and situations.

Instead of choosing between promoting OSS and open standards on the one hand and promoting the interests of IP holders on the other hand, EU policymakers might try to strike a balance between the needs of IP holders and IP implementers. To achieve this, it would be helpful to mount a multi-stakeholder effort to redefine FRAND terms for the licensing of standard-essential patents. Moreover, policymakers should consider developing a model for SEP licensing that is akin to the fair licensing framework in copyright law. Thus, licensing conditions could change depending on the intended use of the SEPs and the type of user. A public institution such as a university would be treated differently than a commercial firm wanting to implement an SEP, and an organization using the IP to create a public good would be treated differently than one selling a product or service. American electric vehicle and clean energy firm Tesla implemented such a policy for its patent portfolio a few years ago (Musk 2014). Developing new licensing models for standard-essential patents is, however, a topic that merits elaboration in a separate project.

10.2. Influencing the Governance of OSS and Open Standards Globally

The EU is in an excellent position to influence the governance of open source software and open standards worldwide. As mentioned above, the EU has a well-developed and complementary system on the EU and member state levels for drafting and promoting standards that are a key component of technology development. The input and preferences of member states' national standards bodies are aggregated at the EU level by the European standardization organizations CEN, CENELEC, and ETSI. Speaking with one voice and giving timely input in turn has allowed EU industry to be highly influential in international standard development organizations (Büthe and Mattli 2011). The strong position of European interests thanks to having highly complementary domestic and EU-level institutions for international standards development is

further strengthened by the large number of secretariat positions in important technical committees. In the two most influential SDOs, the ISO and the IEC, EU countries' national standards bodies hold, even after Brexit, "far more leadership positions than any other major economic power, such as the United States, China, the BRICS (Brazil, Russia, India, China and South Africa)" (Fägersten and Rühlig 2019, 3).

One area that deserves more attention is de facto standard setting. After all, SDOs are not the only fora in which standards are being developed. Oftentimes, industry players form consortia in order to create standards that lower transaction costs, but the standards, or more precisely the IP built into them, often remain proprietary (Baron, Ménière, and Pohlmann 2014; Büthe and Witte 2004; Hawkins 1999; Winn 2009). Standards consortia that are formed to work out a clear technology roadmap ahead of formal standard-setting processes can nonetheless have efficiency-increasing effects that remedy inefficiencies inherent in these processes (Baron, Ménière, and Pohlmann 2012). In cases in which standards developed by formal SDOs suffer from underinvestment because there are insufficient rewards for standard-essential patents, consortium membership triggers a higher number of patent files, which is necessarily pro-efficient. Vice versa, in cases in which excessive rewards induce patent races, consortium membership only moderately increases or even decreases the volume of patent files. The latter effect, at least, is efficiency-increasing as well (Baron, Ménière, and Pohlmann 2012, 1).

Moreover, Aija Leiponen (2005) has found that small firms' participation in industry consortia and other private or semi-public standard development fora (e.g. industry associations) helps these firms to learn about new technological and market developments from the leading players of the industry. Small firms therefore benefit from participation in private standards consortia. However, access to consortia is not necessarily open to all firms (Büthe and Mattli 2013, 39) and these organizations moreover act mostly outside of official oversight. Therefore, public policymakers might consider setting rules and incentives that encourage consortia activities of smaller firms and ensure that consortia are open to all interested would-be participants (Leiponen 2005, 40).

In sum, the EU should continue supporting the important work of CEN, CENELEC, and ETSI and should seek to ensure that there is close collaboration and alignment among the European Commission, the European standardization organizations, and the national standards bodies so that European industry can speak with one voice at the international level. Additionally, EU companies should be incentivized to form – openly accessible and transparent – industry consortia that quickly create de facto standards, allowing European companies to capture first-mover advantages. Policymakers might want to make the provision of incentives dependent on these organizations' playing an efficiency-increasing role that allows for the alleviation of inefficiencies in formal standard-setting processes (rather than the opposite). Given the EU's influence in international SDOs, de facto standards developed by EU companies have a high chance of being adopted as de jure standards by these organizations. EU public institutions can support European companies' efforts by continuing to include suitable industry consortia

standards in public procurement guidelines and established global consortia in official programs and grants.

10.3 Fostering the EU's Goals Through the Promotion of OSS and Open Standards: Policy Recommendations

As detailed in section 10.1 above, promoting the uptake of OSS and open standards can help governments to reduce their ICT budgets, gain more control over the software they're using, support competition, innovation and therefore – potentially – economic growth, discover and punish anticompetitive behavior by market participants, and interact with citizens in a more open, transparent, and accountable way.

The adoption of OSS and open standards by governments can also increase democratic participation, which might help to counteract political apathy and disillusionment among citizens. For one, the use of open source software and open standards in eGovernment supports interoperability and therefore allows citizens using a wide range of ICT systems at home to engage with their governments. Open source software and software that is based on open standards can also be adjusted more easily to facilitate its use by minority groups with special needs. Moreover, the use of OSS and open standards allows tech-savvy citizens to monitor the activities of their government to ensure that public institutions are not engaging in illicit data collection or deploying biased algorithms. Systems based on OSS and open standards can also be designed in a way that allows citizens to participate in the business of eGovernment in a very direct sense (e.g. by suggesting new applications or new use cases for existing applications that address citizens' pressing concerns). Finally, the use of OSS and open standards in voting systems can enhance the safety and integrity of these systems and therefore safeguard democracy, at least if the voting machines' software is regularly updated and checked for bugs.

Given that the increased use of OSS and open standards by governments (and the increased adoption among businesses and private citizens that governments' example might spawn) brings with it important benefits, but also creates a number of costs, EU policymakers might want to keep in mind the following ten recommendations when deciding whether and how to promote OSS and open standards in the coming years:

1. The benefits accompanying the use of OSS and open standards in government outweigh the costs, but given that there are real costs, EU policymakers should adopt an appropriately narrow and nuanced ICT procurement policy rather than decree that all government ICT needs to be based on OSS and open standards.

2. OSS and open standards are the preferable choice in many, but not all, domains, which means that EU policymakers should endeavor to specify the domains in which the use of OSS and open standards makes sense as a matter of principle.

3. EU policymakers should strive to facilitate the wide adoption of open standards by initializing a multi-stakeholder process aimed at creating clear and predictable rules for the fair, reasonable, and non-discriminatory licensing of SEPs.

4. EU policymakers should also consider adopting an SEP licensing framework akin to the fair use framework in copyright law in order to allow for changed licensing conditions depending on whether the implementer is a public or a private institution and whether the SEP will be used to create a public or a private good.

5. Since OSS developers do not always prioritize interoperability, EU policymakers should foster interoperability by using procurement guidelines and other policy tools to incentivize the creation of open source software that implements open APIs.

6. EU policymakers should promote private standards consortia through policy incentives if these consortia have an efficiency-increasing effect.

7. Given the importance of providing timely input and speaking with one voice in international standards organizations, EU policymakers should strive for close coordination with the member states' national standards bodies and the European standardization organizations with regard to both substantive positions and ways of working.

8. Since the use of open standards in government ICT can increase openness, transparency, and accountability towards the citizenry, EU policymakers should work with the European standardization organizations to promote open standards in global standard development organizations and thereby foster the adoption of such standards globally.

9. In parallel with promoting open standards in global standard development organizations, EU policymakers should seek to promote OSS and open standards globally through international trade and investment agreements.

10. Given the fluidity of the international landscape, and in particular the evolving role of China as a technology superpower and creator of many SEPs for important new technologies such as 5G and the Internet of Things, EU policymakers should consistently monitor political and economic developments to determine whether the EU's open source and open standards policies still serve the best interests of the European Union's businesses and citizens.

10.4 Delineating the Implications of OSS and Open Standards Governance for the EU's Actorness

One of the key goals of the TRIGGER project is to provide answers to an important question: how can the EU increase its "actorness" in global governance? Deliverable 4.4, which focuses on the cross-cutting themes that characterize the EU's policies toward digital technology, will give more detailed responses to this question. The four thematic deep dives in Work Package 7, one of which relates to digital technology, also revolve around actorness. However, to prepare the ground for those more detailed discussions of actorness and technology, we present below a number of tentative conclusions that emerge from our analysis of the governance of open source software and open standards.

Before we do so, it is vital to clarify the core attributes of actorness as it has been defined by the TRIGGER project (see Deliverable 3.1). In our report, we have mostly focused on what the European Commission can do to influence the governance of OSS and open standards in the EU and worldwide. Our rationale for doing so was that the Commission, as the executive branch of the European Union that proposes legislation, implements decisions, and manages the day-to-day business of the EU, has been one of the key actors promoting the use of OSS and open standards both in Europe and globally. The TRIGGER definition of actorness, however, focuses on *all* EU institutions as they relate both to the member states and to external actors.

The TRIGGER actorness model encompasses seven dimensions: three internal dimensions (authority, autonomy, and cohesion), three external dimensions (recognition, attractiveness, and opportunity/necessity to act), and one dimension that influences actorness both internally and externally (credibility and trust). With reference to the domain of OSS and open standards governance, the list below considers for each dimension whether the EU has a high or low degree of actorness.

Internal dimensions

- **Authority** is defined as the EU's legal competences in a specific area, as laid out in the treaties or in issue-specific agreements. The EU lacks competence in public procurement and the treaties also do not contain an explicit competence relating to OSS or open standards. This means that the EU cannot simply instruct the member states to purchase open source software or technologies that implement open standards. However, the EU could claim authority to act in this area based on one specific treaty provision, namely the functioning of the single market. The creation of greater interoperability, in particular, can support the formation of the digital single market. In addition, the EU has a high level of authority in the realm of data protection, which extends to those areas of OSS and open standards governance that are covered by the General Data Protection Regulation. Perhaps because the EU does not hold formal competence in public procurement, it tends

to consult the member states before publishing guidelines on public administrations' use of OSS and open standards. Thus, the first European Interoperability Framework (EIF), published in 2004, was the outcome of close coordination between several EU Directorate Generals and the member states' relevant ministries (Karel de Vriendt, phone interview with Nora von Ingersleben-Seip, May 27, 2020). The European standardization organizations provide another arena for informally promoting OSS. For example, ETSI (2019) signed a memorandum of understanding with the Linux Foundation last year, and the European Commission published a joint report with the Open Forum Europe (2017) recently, in order to make sure that OSS developers implement standards and that SDOs adopt OSS development methodologies. However, the EU's new data strategy (European Commission 2020) and the upcoming legislative initiative on the governance of data spaces move away from informal coordination between the Commission and the member states by bringing more competences to the EU level (see, e.g., Prinsley et al. 2020).

- **Autonomy** refers to the EU's capacity (including its resources) to set its own priorities and act independently of the member states. While it is not possible for the EU to directly tell the member states to use open source software and open standards, the EU can publish Directives that instruct the member states to make their public services more interoperable, which increases the likelihood that public institutions in the member states will adopt technologies based on open source software and open standards. The EU can also use its own, internal procurement mechanisms to promote OSS and open standards. Thus, in its latest open source software strategy, the European Commission (n.d.-b) commits to equal treatment of open source software in internal procurement, stating that "[t]he Commission will ensure a level playing field to open source software when procuring new software solutions." In addition, the EU has significant agenda-setting powers in the area of OSS and open standards governance. Thus, the EU's reports and websites on this topic frame OSS and open standards not only as important enablers of interoperability but also as means for lowering governments' ICT costs and enhancing Europe's digital sovereignty. The latter objective has become increasingly more important to the EU, as manifested by the focus on data autonomy in its recent Communication "A European Strategy for Data" (European Commission, 2020).

- **Coherence** refers to the level of consistency between EU and member state institutions, but also between different EU institutions and in general within the EU *acquis*. While there are variations in the extent to which member states have adopted technologies based on OSS and open standards, there is broad alignment on the value of increasing governments' use of OSS and open standards. The EU has moreover worked closely with member states' national standard development organizations to draft joint positions

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that the European standardization organizations – CEN, CENELEC, and ETSI – can bring to the negotiating table in international standard setting processes. However, while the EU has been successful at influencing global standard setting, there is room for improvement. Specifically, the EU needs to make sure that there is better alignment in terms of planning activities, strategies, and ways of working among the European and national standard development organizations. Additionally, there are a number of inconsistencies between the EU's stated commitment to promoting OSS and open standards and its actual behavior. For example, despite its intention to use more OSS internally (European Commission n.d.-b), members of the European Commission conceded to investigative journalists in 2017 that the Commission was "in effective captivity with Microsoft" (*Investigative Europe* 2017). The Commission also gradually moved away from requiring that any IP contained in open standards be licensed for free. While this was still a requirement in the 2004 EIF, the second and third versions of the EIF, published in 2010 and 2017, respectively, allowed for the FRAND licensing of standard-essential patents. FRAND licensing helps to strike a balance between the needs of SEP holders and implementers, but it also makes it more difficult for open source software programs licensed under "copyleft" licenses to implement open standards.

External dimensions

- **Recognition** refers to international perceptions of the EU in a given governance domain. Thus, recognition of a particular actor is high when the actor in question is viewed as an influential actor or an important negotiating partner in a particular domain. After an initial surge of policies promoting OSS and open standards in the early 2000s, activities in this realm of governance have slowed down. However, the EU's policies certainly served as an example, particularly for developing countries looking to increase their digital sovereignty, in the first decade of the 2000s. Thus, after the EU published the first EIF in 2004, many countries in Asia and Latin America also drafted policies that aimed to increase public institutions' uptake of open source software and open standards. In more recent years, the EU's OSS initiatives seem to have inspired policymaking in the US. In 2016, the US government published a federal source code policy that promotes the use of OSS by the federal government and encourages government agencies to share OSS code with the wider public. The European Union's open source activism seems to have died down somewhat over the last few years, however. Thus, the Commission's open source strategy (European Commission n.d.-b) has not been updated since 2017. Moreover, the EU has long advocated the creation and protection of intellectual property rights in global standard development organizations. While the EU's stance is understandable given that European companies are among the world's largest SEP holders, it undermines the promotion of open standards, at least to a certain degree, and

likely lessens the EU's recognition in the domain of open source and open standards governance.

- **Attractiveness** is determined primarily by the extent to which external actors perceive it as advantageous to cooperate with the EU in a given policy area. Such perceptions could be driven either by the promise of material gain from cooperation or by the EU following best practices that others want to emulate. While international cooperation on OSS governance has been limited, the EU is viewed as an important and influential cooperation partner in standard-development processes. As described in section 10.2 above, the EU holds many key secretariat positions in international standard development organizations and therefore often drives new standards initiatives. Other countries might want to cooperate with the EU in order to capture the gains from co-developing technologies that become certified standards and are therefore adopted by a wide variety of market participants. The EU also has extensive technical knowledge and vast experience in developing standards, which makes it an attractive partner for emerging economies eager to adopt best practices. However, the EU will only remain an important actor in this realm if it manages to develop standards that are relevant for novel high-impact technologies such as 5G and the Internet of Things. The EU's position as a key standard setter is increasingly challenged by China, which is chairing important SDO committees that develop standards for 5G, the Internet of Things, and Artificial Intelligence.

- **Opportunity / necessity to act,** the last external dimension of actorness, refers to the existence of external conditions that create a window of opportunity for the EU to act and increase its influence on global governance. Such a window of opportunity opened up in the early 2000s, for example, when the discovery of US National Security Agency backdoors in Microsoft's Windows operating system made other countries question whether it was safe to use proprietary, closed-source software sold by US companies. Shortly thereafter, the EU published the first EIF and many other countries also adopted pro-OSS and pro-open standards regulations. Given recent discussions about digital sovereignty and the emergence of a host of disruptive technologies such as AI, extended reality, and quantum computing, the EU in principle has the opportunity to shape standards and regulations governing these technologies. At the moment, the EU is not seen as a leader in AI development. However, it could become a leader in regulating AI by fostering the design and usage of ethical artificial intelligence.

Cross-cutting

- **Credibility and trust** refers to the reputation and support the EU enjoys in a particular policy domain within and outside the EU. Given the European Commission's long history of promoting OSS and open standards as well as its long-standing engagement within global standard development organizations, we believe that the EU enjoys a high level of credibility and trust in this domain. The challenge now will be to continue promoting openness in a global context in which many countries are pushing for closed, intrusive, government-controlled technologies. If the EU would like to retain its reputation as a leader in the domain of OSS and open standards governance, it will have to ensure that open source code and open standards are incorporated in emerging key technologies.

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