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Experiments at the Frontier of Technological Revolution

Commons, Markets and Public Policy

Free and Open Source Software as a Laboratory for the Information Paradigm

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Barcelona, 28th May 2018

EXECUTIVE SUMMARY

The success of free and open source software (FOSS) is a phenomenon that has not still been adequately studied and elaborated in **economics and political theory**. Yet FOSS has proved to be a laboratory of social, economic and institutional innovation that is highly relevant to the information paradigm generally.

Not only did FOSS emerge in the area of software, that is in the **core technology of the information and communications technology (ICT) revolution**, where it is also about to become the standard model of production, its innovative arrangements have also inspired similar developments in many other domains.

The most distinctive feature of FOSS is that it is organized around **a commons**: that is, a resource that is governed by licenses that allow anyone to access, use, copy, modify, develop and redistribute it. This has substantial implications for modes of governance and for forms of generating and appropriating value.

Thus FOSS is the clearest evidence of the potential role that new types of common goods are about to play in the emerging digital networked economy and society. Similarly, its surprising trajectory sheds new light on the **newly established field of study** that has developed around the rediscovery of the notion of the commons in recent decades.

In this sense, while the first wave of studies on the commons was based on a definition of it as an autonomous sphere distinct from the market and the state, the evolution of FOSS indicates the importance of studying how these new commons tend to be governed in **hybrid configurations**, as for example in their interaction with markets.

The successful integration of FOSS into the market and capitalist competition necessitates a review of the initial attempts to understand this production model. For example, experience has shown that FOSS can be used to strategically achieve new forms of **centralization** and the concentration of power and value.

Likewise—despite its idiosyncratic form, which prohibits any form of exclusive appropriation—FOSS has demonstrated that it can **expand** in parallel with **new markets**.

In order to visualize the relationships between FOSS and markets, a synthetic framework is proposed that is organized around three concepts: **the semi-commons, shared infrastructures and ecosystems generation**. Each of these allow us to visualize the interactions of a multi-layered structure of property regimes, and value production and appropriation regimes in different ways.

While the transition to FOSS in the market is consolidating, public administration and **public policy** are **still struggling** to find a way to engage productively with this new model of technological development and production.

Public policy that promotes FOSS began early and has been widespread. Yet **no** clear **model** has emerged to date and there have been numerous setbacks.

The **reasons** for public administrations to support the use and development of FOSS are both **economic** and **political**. FOSS promises to reduce costs and risks, and increase independence and transparency in the management of critical resources, services and infrastructure.

To date, public policy has underestimated the obstacles generated by the legacies of the past, such as the **lock-in mechanisms** resulting from the integrated ecosystems created by proprietary hardware and software producers, and the fragmentation of alternative solutions, which can lead to an underestimation of the **costs of integrating and maintaining** isolated systems in an extremely dynamic hardware and software environment.

However, a reversal of the trend is taking place, as **FOSS is becoming the new standard** approach at the frontiers of innovation (such as cloud computing, the Internet of Things, data centers, artificial intelligence,

and blockchain technologies). As a result, there is a strong, **worldwide** trend towards its use and development in **public policy**. Hundreds of public organizations are currently engaged in a process of learning by doing in FOSS development.

Nevertheless, as FOSS will play a central role in the new generation of software services, public administrations should not overlook the **risks of new traps** and dependencies. This is especially important now that the FOSS ecosystem has entered a consolidation phase.

Addressing this challenge, EU policy should move beyond approaches based on abstract principles such as technological neutrality, open standards, and impartiality in public procurement, which have proved difficult to apply and **ineffective** in preventing the capture of public administrations by private monopolies and suppliers' lock-in strategies.

At the same time, it is likely that the increasing role of FOSS in the provision of critical infrastructure and its maturation as a production system will drive **further institutional innovations** in the FOSS ecosystem. And one of the most important areas of innovation could well come from increased involvement on the part of the public sector.

Looking forward, three directions can be glimpsed as emerging fields of innovation in public policy:

- an active policy of **standardization**, as a lever for governance and productivity generation;
- the employment of **mixed forms of governance** that blend state, market and commons-based mechanisms; and
- the development of **new forms of public-public cooperation**.

1. INTRODUCTION

1.1 A SURPRISING PHENOMENON

In the last year and a half, two events have shaken the free and open source software (FOSS) world. They are two opposite U-turns that, taken together, convey a paradoxical and contradictory message about the health of FOSS.

The first was the **City of Munich's** decision to abandon its more than ten-year commitment to a Linux-based operating system and return to Microsoft Windows, which is proprietary. Munich has long been regarded as the most successful case of a public administration adopting FOSS. The announcement was therefore received as a dramatic setback by FOSS enthusiasts and the many supporters of FOSS adoption in public administration.

Fig. 1. Munich's U-turn

The second event occurred just a few months later: **Microsoft** announced the acquisition of **GitHub**, the main platform for FOSS development, for 7.5 billion US dollars (almost four times the most recent evaluation the startup had received). Given the historical antagonism between Microsoft and FOSS, the news shocked many. But in reality the acquisition is the culmination of a process of repositioning on the part of Microsoft. In recent years, Microsoft—long the most fierce "enemy" of FOSS—has attempted to show that it has a friendly relationship with the FOSS world.

Fig. 2 Microsoft CEO Steve Ballmer. Jun 2, 2001

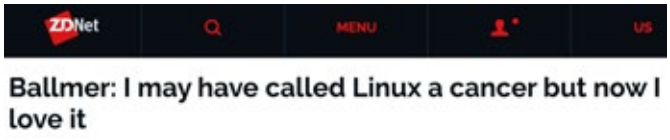

Fig. 3 Former Microsoft CEO Steve Ballmer. March 11, 2016

It has done this through an intense public relations campaign—with slogans like "Microsoft loves Linux" or "Microsoft loves Open Source"—and with concrete and substantial commitments, such as establishing partnerships with Ubuntu and the Linux Foundation. Even so, the acquisition of GitHub marks a leap forward in this U-turn. And shortly afterward, Microsoft made another stunning announcement: The world's largest software company joined the Open Invention Network (OPI), an alliance of hundreds of companies committed to foregoing patent infringement claims in Linux-based technologies. The move was doubtless an attempt to reassure the millions of developers and hundreds of thousands of organizations hosted on the GitHub platform, who after the announcement of the acquisition were tempted to flee to alternative platforms. By joining the OPI, Microsoft contributed 60,000 licenses to the consortium. This figure gives an indication of the chaotic jungle that the application of the logic of intellectual property rights to software licenses has generated—itself a major reason for the progressive success of open source—but also of Microsoft's real decision to integrate itself organically into the open source ecosystem.

Fig. 4 Microsoft's U-turn: A poster used in Microsoft's campaign

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So, what's going on around FOSS? Taken together, these two events seem to convey a very contradictory message. Should organizations keep away from it to avoid problems, like Munich? Or should they be willing to pay any cost to take advantage of its strengths, like Microsoft?

There seem to be **two distinct realities** behind this contradiction. The first is the indisputable **success** of FOSS in the industry. Especially in the last decade, its penetration has scaled to such an extent that it is on the way of becoming the standard model for software production. Microsoft's "conversion" has in fact been forced by the need to confront this reality. The second is what must be considered a substantial **failure** that has so far characterized the ability of public administrations and public policy to productively and successfully engage with FOSS as a new model of technological development and production.

There is already enough substance to this contradiction for us to seek an explanation for it. However, two further recent developments give a further indication of the epochal change that has occurred around open source software, and how necessary it is to adjust our perceptions and interpretations of this phenomenon. In June 2018, the European Commission ordered Google to pay a staggeringly large fine for abusing its dominant position in mobile telephony, obtained with its open source operating system Android. While in October 2018, IBM—trying to catch up with Microsoft—announced the acquisition of the biggest open source services company, Red Hat, for 34 billion US dollars, about 40 percent more than its stock market value. It was one of the largest acquisitions ever made in the world of technology.

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Free and open source software has become a core protagonist in the **gigantic transformation** that is reshaping our societies through the diffusion and penetration of digital technologies. Open source software has become the **new standard** in software development, that is to say, in the central industry of the new digital paradigm. It has become the central basis for capitalist competition at the frontiers of innovation. But it is also a world in which collaborations between thousands of companies are developing in new ways and on an unprecedented scale.

Two catchphrases that become popular in quick succession succinctly summarize this evolution. In an article in the *Financial Times* in 2011, Marc Andreessen wrote: "Software is eating the world". The motto spread virally, as it reflected the growing awareness about how software and digital transformation are going to penetrate and reshape every atom of the social fabric. But shortly thereafter, in 2013, the annual *Future of Open Source Survey* made a further claim: "Open source is eating the software world". And nothing seems truer in light of what has happened since.

It is a rather surprising parable for a phenomenon born on the margins of the industry, in informal communities of autonomous developers, who, without organizations or resources, ended up inventing a decidedly unconventional way of organizing the production of software. For a long time, one thing more than any other has upset the IT world: that the freedom to study, use, modify, reproduce, and redistribute, which all free software or open source licenses allow for, make the software practically unsaleable—which is an exciting or frightening development, depending on your perspective. You can sell services related to the software, but the software itself ceases to be a commodity. It becomes a good accessible to all: **a modern commons**. Yet despite its idiosyncratic form regarding commercialization, the main forces behind the success of FOSS in software development have now become part of the market and capitalist competition.

Nevertheless, FOSS remains the most powerful manifestation of what Elinor Ostrom, in the last years of her life, named the "new commons" (Hess and Ostrom 2007)—sometimes also called the digital, information or knowledge commons. Traditional commons—which Ostrom dedicated her life to studying—are typically inherited from pre-capitalist societies. Whereas the new commons have emerged on the opposite side of capitalist modernity. They are new institutional arrangements that have been invented on the frontier of the most recent technological revolution.

FOSS is the blueprint of these new commons and nothing testifies better to how new kinds of commons are going to play a central role in the future of information and network economies and societies. Yet its evolution also testifies to how the rediscovery and the strategic use of these new commons can take different and contradictory shapes. It

also makes clear more generally that FOSS and the new commons are still a novelty, and that much work is needed to understand and effectively manage them.

The surprising evolution of a phenomenon that, born on the margins, generates a new type of institutionalism, and becomes hegemonic in the most important industry of the current technological revolution, has not yet been adequately understood in economic and political theory.

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To put it simply, the main protagonists of the rise of FOSS to date have been of two types: new forms of **communities of highly qualified workers**, in its initial phase, and the **forces of competition and capitalist innovation**, in its second and current phase. This study aims to explore the possible contours of the participation of a third player, which currently seems to have remained on the sidelines and has not yet found a way to integrate effectively into this new productive environment: the **public sector**.

The first section presents a brief summary of the evolution of free software, from its beginnings to its success in the private sector. The second section offers some reflections on the phenomenon of the new commons in the light of the trajectory of FOSS. The third section takes stock of state of the art of public policy regarding FOSS. The fourth section provides an interpretation of the poor results achieved so far by such policy, which will also serve to explain (as we shall see below) the turning-point that has taken place at the level of private enterprises. Finally, the fifth section identifies some emerging and innovative lines on which a new generation of public policy could be tested. In concluding, I reaffirm the significance of this phenomenon for the current change of productive paradigm, and the importance of deepening our capacity to govern this new model of production, management, and innovation, which is set to regulate the core functions of the future information society.

2. THE EVOLUTION OF FREE AND OPEN SOURCE SOFTWARE

2.1 FREE SOFTWARE

Although there were cases where software was freely shared in the academy and the industry in the 1960s and 1970s, the origins of free software are at the beginning of the 80s. They are typical of a **social movement**. The trigger was the expansion of intellectual property rights (IPR) to software, which began at the end of the 1970s and which clashed with the habits and values of software developers and researchers, who perceived it as barrier to their freedom and a burden on their productivity. It was Richard **Stallman** who laid the foundations of the movement, organizing it around what he called the four fundamental freedoms of the user in relation to software, and a new type of license—the **General Public License** (GPL)—aimed at protecting those freedoms (see Fig. 5).

Fig. 5 The Four Freedoms proclaimed by the Free Software movement.
Source: Free Software Foundation

But it was only with the advent of the World Wide Web in the 1990s that the movement really took off. Developers all over the globe, with highly diverse motivations—which were not primarily or directly economic—began to coalesce around common projects and to experiment in innovative forms organizing software development, forming new types of communities based on collaboration, voluntary contributions and original forms of governance. Examples of the latter included the role of a "benevolent dictator", or the "right to fork", which allowed communities to react to unaccountable leaders by cloning the software and forking the project. With varying blends of ideological and pragmatic values, these loose-knit communities discovered and experimented with mechanisms that anchored and fostered collaboration among dispersed and very diverse individuals and motivations, in the absence of institutional ties, direct economic transactions, or formal hierarchies.

The main innovation, however, was around property rights. The GPL license created by Stallman—as with all licenses that flourished in the FOSS world—actually involves the radical overturning of the principle of exclusivity enforced by, and central to, intellectual property rights (IPR). The original rationale for this institutional innovation was that it guaranteed that nobody could withdraw and appropriate for themselves a resource that had been collaboratively produced, thus undermining the fundamental freedoms. The copyleft clause was added to the GPL with the explicit intent to extend its principles onto any further development.[1] Yet these new licenses also served to provide a surprising new anchor that functioned—under certain conditions—as **a new institutional arrangement that fostered collaboration** and trust, and organized independent and dispersed contributors (Weber 2004). In this way, pragmatically, the autonomous forms of organization that emerged around FOSS turned out to be a critical experience in the rediscovery or reinvention of the commons at the new frontier of the digital revolution.

As Yochai Benkler—one the most sophisticated analysts of this phenomenon—recently recalled, "When free and open source software emerged to public consciousness in the late 1990s, it was an 'impossible' phenomenon. Here were thousands of volunteers, cooperating on developing some of the most complex software infrastructure on the model of a commons: anyone could contribute, no one had exclusive rights to use, adapt, or distribute the software, and most people contributing were not paid to do so. That this mission-critical infrastructure was being built on a mostly volunteer, fully non-proprietary model, in direct competition with the world's largest software firms, was a complete mystery to the prevailing economic wisdom of the time." (Benkler 2019).

1 FOSS licenses lacking this clause are said to be "permissive".

These characteristics and the success of these initiatives stimulated a wave of studies that mainly investigated developers' motivations in the absence of direct monetary incentives, and the models of government and organization in situations where there was no possibility of exercising direct hierarchical command.[2] Looking at these experiences, Yochai Benkler suggested that we were observing the emergence of a third model of production, distinct from both the market and the institutional public sphere, which he called "commons-based peer production" (Benkler 2006).

BENKLER'S DEFINITION OF COMMONS-BASED PEER PRODUCTION

"*when no one uses exclusive rights to organize effort or capture its value, and when cooperation is achieved through social mechanisms other than price signals or managerial directions*."

(Benkler, 2004)

2.2 OPEN SOURCE SOFTWARE

The initial characterizations of FOSS were often of a utopian and anarchic hue. And even today, FOSS is sometimes considered a sign of an emerging post-capitalist mode of production (Bauwens 2005; Vercellone et al. 2015; Rifkin, 2014; Mason 2016). However, the surprising growth of FOSS would have not occurred without increasing engagement in its use and development by private companies. This was actually the conscious objective of the **open source movement**—a **business-friendly branch** of FOSS—that split from the free software movement at the end of the 1990s.

Companies needed time to become familiar with and learn to deal with this new production model and to rely on it. Even today it remains a kind of riddle for most managers. Over time, with its open and collaborative philosophy and its basic principles, FOSS also inspired a wave of innovations in other domains: in the production of content, knowledge, art, education (Creative Commons[3]), science (open science, open access), data (open data) and even infrastructure (communication networks), manufacturing (open manufacturing, open hardware) and government practices (open government).

And although attitudes are changing, the most common reaction is still what in FOSS communities is called FUD syndrome: that is, fear, uncertainty, and doubt.

One of the basic reasons for this is that for a commercial mindset, the FOSS model is counter-intuitive, as it allows anyone to access, use, modify and redistribute the resource produced. For this reason, these commons have been defined as "open access commons" (Benkler 2013). This characterization also emphasizes how such a regime conflicts in various ways with the features, dilemmas and principles of governance that Ostrom (2015) elaborates in her studies on the traditional commons.[4] One of the most important differences is that these new commons typically flour-

2 See for example: Kollock, P. (1999); von Hippel and von Krogh (2003); Lakhani and Wolf (2005); David and Shapiro (2008); O'Neil, M. (2009).

3 In 2016, it was estimated that more than one billion works had been made available through Creative Commons licenses, for example.

4 Much of Ostrom's work aims to refute Hardin's famous 'The Tragedy of the Commons' (1968). One of Ostrom's central criticisms of Hardin is that he confuses resources in a regime of open access with actual commons, which Ostrom argues imply a system of governance and a community in charge of it. Moreover, among the principles that Ostrom outlines for a commons to be effectively governed, the principle of a clearly defined border within the community around those users allowed to access and use the resource stands out.

ish around resources that are non-rival.[5] So they are not threatened by the risk of over-exploitation and depletion, which is the central dilemma in Hardin's 'The Tragedy of the Commons' and also in Ostrom's studies. On the contrary, as various authors have pointed out, the looming tragedy for these commons is a scarcity of use, adoption and development (Schweik and English 2012; Coriat, 2011). Weber also coined a term to characterize these kinds of goods: "anti-rival". That is, the more people share these goods, the greater their value is for everyone.

But what is most relevant from the perspective of a commercial company is that the FOSS model by its very nature undermines "the right to exclude", possibly the most important characteristic of private property (Rose 1986), or it undermines the exclusive rights of the owner that, as Benjamin Coriat (2015) puts it, represents "the alpha and omega of the 'bourgeois' right of property". And this has the significant consequence of undermining the possibility of selling the property or the right to access and use a resource, and in this way appropriating and capturing its value. So to some extent, the involvement of companies in the development of FOSS means that they are producing public goods (in the original sense as defined by Samuelson and Arrows, i.e. a good that is both non-excludable and non-rivalrous[6]) and that they are participating in—or adopting strategies of—selective **de-propertization** and **decommodification**. Considered from another perspective, they are engaging with and contributing to the expansion of a modality of value creation and appropriation that is radically distinct from the market, as it is based on sharing as a means of creating value. It is therefore not surprising that for a long time the common perception of FOSS was that it would undermine and disrupt software markets. This meant it was relatively easy for Microsoft—then the arch-enemy of FOSS—to depict free software as a "cancer" and FOSS communities as a bunch of "hippies", "new communists" or "anti-Americans". Microsoft could easily stoke these instinctive fears in its smear campaigns. For these same reasons, the penetration of FOSS in the private sphere initially came up against both **mental barriers and very real barriers**. Overcoming them required time, experiments and innovation.

2.3 UNEXPECTED SUCCESSES IN THE PRIVATE SECTOR

Nevertheless, step by step, a growing ecosystem of companies progressively joined or formed around open source projects; and new projects were initiated directly by companies. FOSS expanded slowly but surely. In certain areas, such as web servers, browsers, and content management systems, early FOSS solutions were produced that would come to dominate the market. This growth sometimes followed paths that were difficult to imagine at the beginning. Linux, for example, has not had massive success as an operating system for personal computers, as was the initial aim of its developers. In personal computers, Microsoft's Windows maintains its dominance. But Linux did manage to become a dominant platform in other areas such as servers and web servers. It was for the latter that Linux began to be used by large organizations with supercomputing needs, like NASA or later Google, from the mid-1990s onward, exploiting it to build huge and relatively inexpensive data centers and processing capacity.

In this sense, FOSS and the Linux operating system in particular, which had often been celebrated for the democratization they were supposed to bring to software production and to a crucial layer of technological innovation, provided a potent foundation for what is today considered to be the "industrialization" and "**platformization**" of the internet—key features of its present extremely concentrated architecture.

This evolution points to a paradox that is often overlooked: **the FOSS model of open access did not prevent, but rather enabled**, the unequal exploitation and appropriation of its common value, and so allowed its development to

5 A good is considered rival if its consumption by one person prevents or reduces the possibility of others to consume it. Whereas a good is considered non-rival, if once it is produced, the cost of providing the access to it to an additional (marginal) user or consumer tends toward zero. The same characteristic is sometimes labeled as subtractable or non-subtractable.

6 Though in this case, the non-excludability depends not on its nature, but on the property regime of comes under. In conventional economic theory, in a market framework public goods lead to problems of under-provision and underproduction (Arrow 1962).

follow such asymmetries. A second historical shock in the rise of FOSS occurred in around 2008 with the arrival of Android. Android is a mobile operating system built on the Linux kernel, and was introduced into the mobile sector by Google as part of a cunning open source strategy that revolutionized the world of mobile telephony.

ANDROID: THE FASTEST-GROWING TECHNOLOGY PLATFORM IN HISTORY

Open sourcing the mobile operating system Android was Google's strategy to enter the mobile internet market in order to defend its own applications (like Google search, Google maps, Gmail, etc.). With the intent of rapidly penetrating the sector, Google managed to quickly assemble a vast, global and extremely varied ecosystem of actors around Android. At its core is the Open Handset Alliance (OHA), formed at the launch of Android in 2007 and consisting of hardware manufacturers, mobile network operators and software companies; they were soon joined by a multitude of independent app developers who rapidly enriched the platform with millions of new applications. In less than five years, Android reached one billion users, thereby becoming "the fastest-growing technology platform in history" (Pon et al. 2014). As of today, it is far and away the most popular operating system on mobile devices.

Android eating red apple - Source: HD wallpaper

Android demonstrates how FOSS can be used as part of a highly successful strategy to compete at the new frontiers of innovation. Since then, this model has spread, so much so that today it is very common. But in other areas of development, FOSS solutions are instead emerging as an arena for convergence, **standardization and industry-wide forms of collaboration**. The most popular platforms for software development have incorporated the logic of the "fork" into their architecture. Initially considered a tool to be only used in the last instance, e.g. for communities to keep a project's leadership accountable or to resolve internal conflicts, it has since become an ordinary and default mechanism, facilitating the parallel development of workflows on the same program.

In any case, it was this hybridism between communities, companies and markets that gave FOSS a decisive push forward.

It also **changed** the **FOSS ecosystem**.

Projects and ecosystems that maintain community-centered forms of collaboration continue to exist or emerge and continue to be a source of innovative solutions and a laboratory for new ways of organizing production. Often these projects contribute critical resources and infrastructure that support global communication systems and the digital economy. Sometimes they are faced with precariousness and a lack of resources, and exhibit the distortions and opportunistic exploits that characterize, in certain cases, forms of production based on common goods.[7] It is often from this kind of informal community that the most disruptive innovations emerge, as happened recently for example with blockchain technologies. These largely informal coalitions contribute significantly to widespread and accelerated innovation in the digital world. The same explosion of digital entrepreneurship has largely relied upon FOSS. The FOSS commons have dramatically reduced barriers to experimentation and prototyping, and have given a tremendous boost to the entrepreneurship and innovation taking place in the startup ecosystem (Egbal, 2016). The governance of these communities remains an area of experimentation and innovation. Social capital and meri-

7 The recent Heartbleed case demonstrates this in an emblematic way: a vulnerability found in 2014 in OpenSSL, a FOSS security implementation used by hundreds of thousands of organizations, which utilized the resource, without worrying about its production or maintenance. Suddenly, all these organizations realized that this critical implementation depended on a small group of volunteers, passionate but also stressed and exhausted, who had been developing it since 1998 with almost no resources.

tocratic principles are still in place as crucial anchors that regulate the internal functioning of these communities. This is also true of the powerful nonprofit foundations that have emerged and have grown up in the FOSS ecosystem.

However, the relationships of most of these foundations, and of the broader ecosystem, to market forces and corporations have radically changed. Companies have learned to participate and to strategically feed resources back into these communities, influencing the productive environments in different ways. The monitoring and connections have become capillary, increasing the speed and ease with which the most "promising" innovations are picked up, adopted and integrated by venture capital, tech giants, or by industry more broadly (as is happening with blockchain technologies in banking, logistics or communication, for example). At the same time, the promise of rapid valorization that these connections sometimes provide to successful startups has become the pole star in the minds of most FOSS developers.

On the other hand, open source has been a laboratory for new kinds of business models and capitalist organizations. Indeed the newest top web companies like Google, Facebook and Amazon would have not emerged or would have not grown so rapidly without FOSS. They have heavily relied on its free resources in their growth and they have deeply engaged with FOSS in their successful—and often disruptive—business strategies. But they also have been influenced by FOSS in their culture, internal organization and business models, and have contributed to FOSS development, giving a strong impetus to its expansion.

3. LESSONS ON THE NEW COMMONS

3.1 RECONSIDERING THE RELATIONSHIP BETWEEN COMMONS AND MARKETS

All of this evolution and the spread of FOSS in the industry requires a reappraisal of the most common critical approaches to the relationships between knowledge commons and the market. So far, most critical thinkers have focused on the threat that privatization and enclosures, via intellectual property rights (IPR), pose to the knowledge commons (Boyle 2003; Bollier 2008). It is indisputable that the suffocating expansion of IPR is still the dominant model of the exploitation of knowledge in information capitalism. The same companies that are deeply engaged in using or developing FOSS solutions in certain areas are also amassing patents and IPR in other areas. However, looking at the spread of FOSS, the idea that capitalism and markets necessarily depend on IPR—a conviction that has more or less united mainstream policies and their critics—stands in need of a more nuanced evaluation, because new forms of capitalism have emerged that can successfully modulate between commons and markets. Moreover, the same success of FOSS can in part be explained as a way dealing with the failures of the IPR system and as a strategy to bypass the barriers, risks and costs that IPR has set up around innovation.

Alternatively, many critical thinkers have described the companies that adopt FOSS as taking an opportunistic "free ride" on the commons provided by the "free labor" of communities of voluntary creators (Terranova 2004). To be sure, such "parasitism" is endemic in FOSS, as it is in knowledge and information production in general (Pasquinelli 2010). As Mazzuccato (2013) points out, the most successful companies often excel in this. And the distortions that cut across the system of generating, distributing and capturing value in the digital commons is one of the unresolved fragilities that renders all FOSS ecosystems extremely vulnerable.

But in other cases the situation has radically changed and is very different. Today the biggest contributors to open source software are corporations like Microsoft, Google, IBM and Facebook. In many projects, most of the labor behind FOSS development is done by workers paid by companies. For example, more than 80 percent of Linux kernel developments are actually provided by company employees. And this situation is becoming common. In many projects, there are often hundreds of companies collaborating in the development of a commons. So from this perspective too, the growth of a selective use of commons in information capitalism—evident in FOSS but also emerging in other areas of technological and scientific innovation—calls for the development of new interpretative perspectives.

3.2 A FRAMEWORK FOR ANALYZING HYBRIDS

Three concepts or configurations can help us analyze this hybridization between commons, markets and capitalist forms of organization within a synthetic framework. They represent rationales that may overlap, but that, separated, provide a means of distinguishing different logics and outcomes.

The first concept is that of the **semi-commons.** It was first proposed by Henry E. Smith (2000), who extrapolated it from an analysis of the medieval open-field system and applied it to modern communication networks. It is based on observations of how medieval common lands historically accommodated two kinds of activities—farming and grazing—and two different property regimes—the commons and private property—that existed at different scales or at different times throughout the year. The idea is useful insofar as it serves to highlight a two-tiered framework based on the coexistence of a double regime of property and economic exploitation within the same system of resources. The kinds of "open business models" that have been emerging around FOSS can be gathered under this heading. It clarifies how, on the one hand, the core value of the software remains a commons that cannot be exclusively appropriated. On the other hand, various forms of commercialization can be derived from it: the sale of services, support, certifications, packed distributions, the use of "freemium" models,[8] the integration of additional proprietary software features, and the integration of the software with hardware and with complementary products (FLOSSmetrics 2010). There are important differ-

8 On this model a basic version is open sourced but money is charged for versions with additional features or services.

ences among these models, yet they all share the same two-tiered structure, which is organized according to two logics: a commons as a shared base, and the different markets that are generated on top of it. This two-layered structure also explains the *cross-subsidizing* base that funds the production of the "public good".

The second idea commonly used to explain companies' adoption of FOSS is that of **shared infrastructure** (Perens 2005; Eghbal 2016; Fogel 2017). This concept likewise proposes a two-tiered structure. The difference is that here the companies are primarily conceived as the users and buyers of software, rather than the producers and sellers of it. This is true of most companies: they are either not interested in software commercialization or most of the software that they do use does not constitute a specific "differentiating component" for their business model. For these companies, then, FOSS provides a way to share and economize costs and risks in the access and provision (development, maintenance, adaptation, and upgrading) of the necessary components of production. This is made easier by leveraging certain characteristics of digital commons, such as the fact that they are non-rival (Frischmann 2009) and that they can be shared at no additional cost (Rifkin 2014). This idea explains why companies that are mostly users of software have been critical in supporting FOSS since the beginning.

Linux is a powerful example from which to draw insights about these mechanisms. Its adoption in the market illustrates both sides of the double logics just described: FOSS as a semi-commons and FOSS as shared infrastructure. While a plethora of markets have been built upon its exploitation, as a common technological base and evolving infrastructure, Linux is also remarkable for its longevity, for its capacity to adapt and evolve, for its use as a base for many diverse applications, and for its unexpected innovative uses and developments.

The third way to frame the hybridism between FOSS and capitalism describes the strategic use of FOSS to **build an ecosystem**. In these cases, it is usually a company that introduces a specific FOSS product, often maintaining control over its development. The strategy typically aims to attract users, developers, and business ecosystems around a new standard or platform, and is designed to exploit the growth or creation of complementary markets that are adjacent and correlated to the FOSS commons. Informational or "surveillance capitalism" (Zuboff 2015)—based on the hoarding and exploitation of user data—has been a fertile ground for these strategies. Google's Android represents the most successful and spectacular example. The recent condemnation of Google by the European Commission for abusing its dominant position proves how such cross-subsidizing can be used as a kind of innovative dumping strategy to wipe out competitors, unleash various network effects and prepare the terrain for new forms of monopolization. But these modalities of competition are increasingly expanding, within but also beyond software. Facebook's Open Compute Project, aimed at sharing knowledge and designs of hardware products for data centers, is an example. Another successful innovative entrepreneur who used this strategy is Elon Musk. He did so with Tesla in the automotive industry, aiming to break its resistance to electric cars and to mobilize the global investments necessary for a hugely costly transition, while leveraging Tesla's leading position, especially in battery technology. He is also trying to use this same approach with his OpenAI initiative, which aims to catch up with the leading companies and emerging monopolies on data and artificial intelligence.

3.3 A NEW RESEARCH AGENDA

As we observed, FOSS represents the most robust evidence for the growing reality of the new commons, and is an innovative way to provide and govern critical resources in the informational paradigm. This reality is still far from receiving any serious recognition at the level of public policy, even though such recognition could potentially have vast implications. The most obvious of them being the questioning of the almost exclusive emphasis on IPR that so far has characterized public policy in the field of knowledge production. But the implications are also much broader than this.

One example concerns value (Berlinguer 2018). The core of FOSS consists in **forms of value or wealth production that are distinct** from and not reducible to those based on the logic of exchange. Since a commons cannot be directly commodified, the bulk of its value is neither realized nor measured by market transactions. Thus, most of its value doesn't leave traces in companies' budgets, consumption statistics or GDP figures. This invisibility is a potential source of various distortions, injustices and dysfunctionalities (Eghbal 2016). And at the same time, it provides a new perspective from which

to investigate the limits of a system of value recognition focused exclusively on the notion of exchange value. This issue is rarely addressed, although attempts have been made to estimate the value of FOSS in monetary equivalents (for example, CENATIC 2010; Licquia and McPherson 2015). But these approaches are overly narrow, as they do not address the distinctive forms of wealth generation that are based on commons, which, as with knowledge production in general (Rullani 2000), amount to a structural "mismatch" with the logic of exchange value (Hardt and Negri 2009). The reasons are numerous. One is that FOSS—like other phenomena in network, digital and information economies—emphasizes a form of wealth generation that originates in the sharing of common resources and that is often multiplied through that very sharing (a characteristic that Weber calls "anti-rivalry"). Yet a form of value that exceeds what is privately appropriable is precisely what existing systems of account seem unable to recognize as value (Vercellone et al. 2015; Berlinguer 2018).

It is remarkable that FOSS is thriving despite not fitting with the dominant regulatory regime of economic production, which is entirely centered around exchange value. The obvious explanation for this is that the FOSS ecosystem and economy is ruled by various overlapping property systems, regimes of value generation and appropriation, and forms of governance. This is what has allowed its integration with market-oriented organizations and capitalist competition.

Considering these developments from the perspective of the emerging field of commons studies, these characteristics suggest the necessity of developing an approach focused on **hybrid or mixed systems**. In a sense, they demand that we go beyond the first wave of studies on the commons, which were preoccupied with rescuing the idea and institution of the commons from a condition of oblivion or even "impossibility", as Hardin argued in 'The Tragedy of the Commons' (1968), the text that set off the whole debate. This first wave struggled (and continues to struggle) over defining the specific features of the commons as a sphere that is autonomous and distinct from the market and the state. But if we consider FOSS, another area that seems at least as worthy of our attention involves the different configurations that the articulation of a commons with other differentiated institutional orders can take (Jessop 2001): for example, the combination of strategies of decommodification, on the one hand, and the creation of new markets, on the other. This multi-layered articulation of technological stacks and legal and economic regimes also seems to be a critical site for investigating new modalities of economic power and governance; as well as for investigating the mechanisms that allow a disproportional capture of the value generated by these complex ecosystems. This has a broader significance for the study of contemporary forms of production and value appropriation.

This also means that, although markets and commons have opposing idiosyncrasies in principle—a commons as such cannot be sold or its value privately appropriated—not only are they compatible, they can even expand in parallel. Markets can be eliminated in certain areas by introducing a commons, only to be also expanded or created *tout court* in others, where they might be facilitated or fostered by those same commons: for example, by reducing the costs of certain products or services or more broadly accelerating the digital transformation of processes, products or outcomes (which destroys previous markets at the same time as creating new ones). Thus—even if it seems surprising—what we observe is that **selective forms of decommodification and de-propertization can arise from within the same market forces** and as a result of new competitive strategies that are emerging in information capitalism (Berlinguer 2018).[9]

There is a further direction of research on the new commons that can be drawn from the evolution of FOSS. Take Linux or Android and consider the size and complexity of the actors involved in its development and in the sharing of this core

9 The role played by capitalist competition also points to a "constructivist" and "political" dynamic as the determining force behind the establishment and success of these new commons. By contrast, several approaches from the contemporary emergence of studies on the commons have instead argued that a determining factor lies in the nature of the resources concerned. Even Ostrom initially used an argument of this kind. In the case of FOSS, the digital "nature" of resources, processes or outputs, have often been assumed to be a determining factor. To be sure, it made possible or facilitated the experimentation with innovative institutional solutions, each with their own strengths and weaknesses. Yet the concrete arrangements, the evolution and the success or failure of these solutions are better understood as the result of the successful governance of a complex play of forces, among which new types of communities of highly qualified workers, at the beginning, and later capitalist competition have been the most determining.

resource. **Which is the basic unit of production in these systems?** Where do we draw the line between internal cooperation and external competition? Clearly, the scale and contours of these systems of production cannot be understood simply by looking at the formal boundaries of a single, closed economic organization. Rather, the basic unit needs to be radically rethought. Seen from this perspective, the new commons appear as devices aimed at creating and directing broad coalitions, and at orchestrating, integrating and managing resources that depend on complex and dynamic interdependencies between a multiplicity of autonomous actors (who moreover often have little trust, ties and reasons to cooperate with each other). This suggests the need to situate the re-emerging of the commons at the frontier of the information and network economy as part of the rise of **new types of economic organization** (Rullani 2009), as belonging to a family of new concepts, arrangements, architectures or "meta-organizations"—such as **networks, ecosystems, and platforms**—that are reshaping and displacing the organizational forms that characterized the Fordist era. This allows us to situate certain corporate practices surrounding these new commons in continuity with other kinds of outsourcing and the orchestration of complex value chains, which Harrison (1997) aptly describes as forms of "concentration without centralization". Google's Android is a good example to understand how both cooperation and competition can be combined in the design of these complex and multi-layered ecosystems and how FOSS can be used to form new sites for the concentration of value or power. Thus, openness, decentralization, autonomy, and disintermediation—features often linked to FOSS—can grow in parallel with the formation of new sites for the concentration of value or power. This requires us to conceptualize their "contradictory" unity (Harvey 2014), which has too often been overlooked and which now seems all the more typical in network and information economies. In this sense, if FOSS commons have contributed to the democratization of innovation, causing a drastic fall in many costs, initial capital requirements and barriers, the diffuse fabric of innovation and collaborative production that emerged alongside this democratization has nonetheless often ended up providing a cheap system for big companies and venture capital to outsource the costs and risks of conception, innovation and production of prototypes.

3.4 FREE AND OPEN SOURCE SOFTWARE AS AN EXEMPLAR IN THE EMERGING PARADIGM

As we have seen, FOSS passed through two different stages in the course of its development. It emerged as a disruptive innovation driven mainly by ethical, political, and social motivations, in communities of developers who created autonomous and unconventional forms of organization around its innovative property model. And now it is well on the way to becoming the hegemonic model of production in the software industry and a diffuse innovative strategy in the most innovative forms of capitalist competition. How should we interpret such an evolution?

One possible interpretation would be to understand this evolution as a typical case of capitalist appropriation, recuperation or **cooptation**. It has often been observed, at least since the 1970s, how critical social movements have become an unexpected source of capitalist renewal. This is the thesis, for example, of Boltanski and Chiapello's 'The New Spirit of Capitalism' (2005). According to this perspective, the FOSS parable can be regarded as a further instance of capitalism's capacity to adapt and renew itself by selectively re-appropriating critical challenges to it. Following Boltanski and Chiapello's thesis, the hackers movement

ROBERTO DI COSMO'S FREE SOFTWARE: 30 YEARS IN A NUTSHELL

Three main phases:

First 15 years, 1984–1998
early movement
focus: freedom for users and developers
keyword: free software

Second 15 years, 1999–2014
progressive industry adoption
focus: software quality and cost
keyword: open source

Today, 2015–
mainstream use
focus: community and governance
keyword: governance

Source: Di Cosmo, 2018

could be seen as having breathed new life into the capitalist system. Thus, for example, FOSS accommodated the desires and needs for autonomy and self-organization of a new and highly qualified intellectual workforce, while at the same time better incorporating the demands of knowledge production and the current wave of accelerated innovation into the work process.

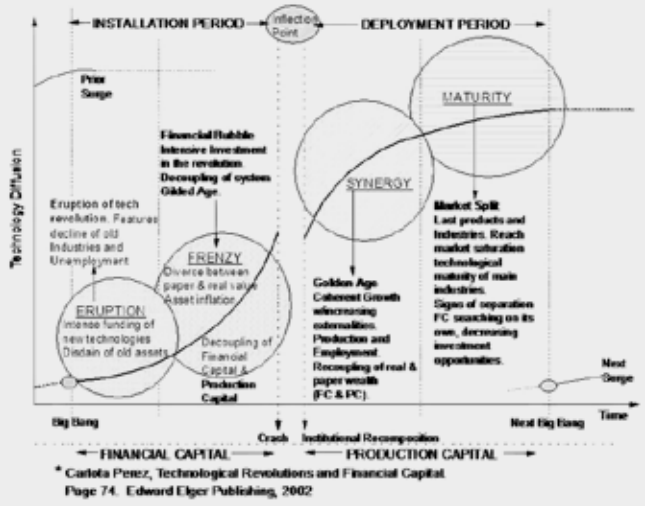
A second possible interpretation could be called **normalization**. In this case the thesis is simpler: as the saying goes, there's nothing new under the sun. Indeed, economic interpretations of FOSS have been proposed since its first manifestations, with economists applying the traits of *Homo oeconomicus* to the voluntary contributors to FOSS: for example, emphasizing motivations such as the development of human capital, reputation, social capital, and employability. Others, inquiring into the reasoning behind companies' participation in FOSS, have looked to the past. It is a little-known but recently rediscovered fact that common pools of patents and innovations between companies played a critical role in other historical technological transitions, such as in the automotive or aviation industries. Sometimes it was under the aegis of states—during the mobilizations of the two world wars for instance—that open and shared access regimes helped to accelerate the full deployment of these new industries. Alternatively, looking at more recent post-Fordist developments, FOSS can be seen as an extension of the alliances in R&D that have characterized the most innovative technological sectors since at least the 1980s and 1990s (Powell, 1989) as well as a radicalization of certain outsourcing practices.

Both interpretations—which can be combined—grasp real aspects of the expansion of FOSS. Yet they tend to trivialize the novelties of FOSS as a production model and as an ecosystem. In addition, they would seem to point definitively to conclusions about a phenomenon that is actually still evolving and should not be considered stable. A more open way to look at FOSS instead involves framing its emergence and evolution in terms of the present **transition to new modes of production**. This allows us to think of FOSS as part of a broader change that is still ongoing, and that could still take different paths. **Carlota Pérez's (2003) theory** of techno-economic paradigm shifts and great surge cycles of technological change, developed within the evolutionary and neo-Schumpeterian tradition, provides a stimulating framework to analyze the present techno-economic shift. This theory is based on some regularities and a recurrent sequence of phases in the social and economic assimilation of previous technological revolutions and builds on the notion of a succession of distinct **techno-economic paradigms**.

PÉREZ'S THEORY OF GREAT SURGE CYCLES

According to Carlota Pérez, new techno-economic paradigms emerge and develop through two distinct phases: the installation period and the deployment period. The first phase, which takes place when a previous paradigm has exhausted its potentials of productivity growth, is led by financial capital and a laissez-faire ideology. This phase aims to override the power of the old production structures, fund new entrepreneurs and foster "a grand experiment" of trial and error. It is a time of "creative destruction", following Schumpeter's definition, and typically culminates in the bursting of a financial bubble. According to Pérez, it is by coming out of the resulting depression that periods of golden age prosperity have been unleashed. Entering into this second period of the technological revolution, however, requires bold and systemic institutional innovations and policy changes. This change usually takes place under political pressure to reverse the polarization of incomes, unemployment and other negative consequences of the dislocations produced by unbridled markets. New policies are put in place to shift the balance of power from finance to production and to shift the focus to expanding the real economy and increasing social welfare. These second steps require governments to intervene to tilt the playing field and push innovation in specific directions. This in turn reduces investment risks and enables productivity leaps through the generation of multiple synergies. This directionality is made possible by exploiting the enormous potential to transform the entire economy and the very lifestyles that emerged embryonically in the first period.

Ultimately, the crises in between the two phases can only be overcome through profound political and institutional changes. This model is best illustrated by the crisis of the 1930s, which exploded in the midst of the installation of Fordist forms of production and required fundamental changes in economic thought, policy and institutional structures.



Following this theory, the world is now in a similar historical moment: suspended in the middle of the transition from the „installation period" to the „deployment period" of the new paradigm. The devastating financial disruptions that have occurred are testimony to this impasse, as is the fact that the management of the crisis has so far failed to bring about any significant political and institutional change. To harness the potential transformation of the whole economy revealed by the digital and ICT revolution, governments should intervene „boldly" and „tilt the playing field" in a particular direction. According to Pérez, that direction points toward a new „global knowledge economy" and „green growth", understood as an increasing proportion of services and intangibles in GDP, world trade, and in our lifestyles.

A paradigm can be thought of as a new common sense regarding techno-economic organizational principles. It spreads when the new forms of exploitation of the set of interconnected technical and organizational innovations that are the basis of each technological revolution not only begin to emerge but also prove to be the most efficient forms, and so most importantly consolidate into new models and organizational principles, displacing old ideas and practices among managers, entrepreneurs, engineers, and inventors.

From this perspective, FOSS can be thought of as a potential "exemplar"[10] for the new information paradigm: as a **laboratory** where **innovative institutional solutions** have emerged as models for new ways of thinking and solving problems in terms of techno-economic organizational principles. The exemplarity or general significance of FOSS in the new productive paradigm can be argued for in several ways. First of all, FOSS emerged in the core and general-purpose industry of the ICT revolution: software. Furthermore, as typically happens in Kuhn's framework, FOSS initially appeared as an anomaly or riddle for "conventional wisdom", and it initially grew at the margins of the dominant model of production. Yet despite being neglected and hampered by the existing legal and economic regime, it succeeded in "installing" a regulatory framework and a new institution—a contractually reconstructed commons—on a matter—knowledge and digital production—that potentially has implications for the whole new paradigm.

If we apply the periodizations that Pérez identifies in each paradigm shift, we can observe that, significantly, FOSS grew steadily and forcefully during the maturation of the new digital paradigm. It expanded from small and marginal beginnings to achieve a core position in software production, and progressively spread across all the nascent sectors: the World Wide Web, mobile telephones, data centers, AI, the Internet of Things, and cloud computing. In this way, it has become a crucial component of the massive new information systems and infrastructures that permeate the new paradigm. And it is now on the way to being integrated in the same core systems of the old paradigm (e.g. banking, finance, state administration, manufacturing, transport, energy, distribution, etc.) and throughout society at large. On the other hand, as has been the case with previous historical changes in "techno-economic paradigms", along with this spectacular growth, FOSS has also been a laboratory for the introduction and diffusion of new organizational forms, systems of governance, innovative business models, and for the development of new forms of capitalism and market competition. So as things stand, the significance of FOSS in the new emerging forms of production seems evident.

10 The notion of "exemplar" was used by philosopher of science Thomas Kuhn, whose primary contribution was the introduction of the concept of the "paradigm shift" (Kuhn, 1962). According to Kuhn, scientific practice alternates between periods of normal science and periods of extraordinary or revolutionary science. During periods of normality, scientists tend to subscribe to a broad body of knowledge, methods and assumptions that constitute the dominant paradigm. Each paradigm is characterized by "exemplary solutions" which provide models that exemplify a certain way of thinking and solving problems.

Pérez' periodizations of previous techno-economic paradigm shifts can also help frame the consolidation that is ongoing in the FOSS ecosystem, which is one of the signals of the maturation of a new paradigm. And it suggests two further points which can be of interest for introducing the role of public policy in FOSS development. According to this framework, we are actually caught in the critical phase that typically marks the passage from "installation" to "deployment". And crossing this passage has historically required **a renewed form of political and public intervention**,[11] as well as a major reshaping of the institutional order. Historically, the state and its organizations have been affected by the consequences of these techno-economic paradigm shifts later than other actors. And it is precisely this delayed adaptation and transformation that forms the main barrier to the deployment of the potential of the new mode of growth (Pérez 2004; Rochet 2009). Because the increasing misalignment of the institutional sphere tends to aggravate the destructive effects of the transformation brought on by the surge of techno-economic innovations.

If the argument about the exemplarity of FOSS outlined above has any validity, one could reasonably expect that it would be around FOSS that innovative solutions would be likely to emerge. But as we shall see, if this is the challenge at hand, we are far from having achieved clarity about the new type of public intervention needed.

11 Thus ending the dominance of laissez-faire and speculative finance-driven policies which instead typically accompany the first period of experimentation of the new paradigm.

4. PUBLIC POLICY AND FREE AND OPEN SOURCE SOFTWARE

4.1 THE STATE OF THE ART: SOME DATA

In theory there are many reasons why the public sector should prefer developing or using FOSS over proprietary software, when financing new projects, in procurement and in its functioning as a public administration. For as we shall see, in theory at least FOSS promises many advantages: cost reductions, a more rational and efficient use (and reuse) of its own resources, the breaking out of technological and economic dependency on a few oligopolists, transparency in code, and a positive and democratizing impact on the opportunities for innovation.

Indeed, advocacy for the adoption of FOSS in public policy and public administration began early, around the beginning of 2000s; and—contrary to popular belief—there have been a significant number of attempts to put forward a FOSS agenda in public policy. Unfortunately, there is **little systematized information and knowledge** about these experiences and their results. In fact the literature and debate on public policy and FOSS has been mostly programmatic, discussing in the abstract the benefits (or the risks) of adopting FOSS in public administration. A good, relatively recent summary of FOSS policy recommendations made by this kind of programmatic literature in the European Union context is provided by Bouras et al. (2014), who identify 25 recommendations organized into five areas (see Fig. 7).

Policy area	Recommendation	Policy level		
		Regional	National	EU
Data openness and reusability (3)	Using open standards on a "comply or explain" basis	X	X	
	Fine-tuning interoperability strategies		X	X
	Defining monitoring and support mechanisms for openness and reusability	X	X	X
Licensing, procurement and software market policies (8)	Defining a clear licensing policy	X	X	
	Developing common licensing policies across the public sector	X	X	
	Monitoring tenders for software discrimination practices		X	X
	Updating procurement frameworks and procedures	X	X	
	An "equal consideration" policy: balancing needs and options	X	X	
	Requiring compliance with interoperability frameworks in public tenders	X	X	
	Setting a "re-use instead of re-build" priority in public tenders	X	X	
	Developing joint procurement policies in fulfilment of shared priorities	X	X	
FOSS adoption, integration and sustainability (9)	Developing FOSS adoption plans as part of wider IT strategies	X	X	
	Allowing for diversity in open-standard software environments	X	X	
	Adapting internal processes to open source environments	X	X	
	Clarifying the legal and institutional framework	X	X	
	Providing guidance and support to small and medium size organisations	X	X	
	Involving staff through FOSS training and awareness	X	X	
	Beyond cost analysis: defining a FOSS assessment policy	X	X	
	Integrating FOSS as a vehicle for regional development	X		
	Supporting public organisations as potential FOSS producers	X	X	
Research and innovation (3)	Investing in FOSS research and development	X	X	X
	Revising the EU software standardisation strategy			X
	Investing in innovative software products and solutions	X	X	X
Training and education (2)	Integrating FOSS as a means to increase ICT skills and e-inclusion	X	X	X
	Integrating FOSS in the educational system on a regional/national level	X	X	

Fig. 7 Policy Recommendations. Source: Bouras et al., 2014

It is also difficult to find organized and updated information about public policy and the public administrations that have or currently are engaging with FOSS, since there are very few places where this information is collected. This leads to a situation in which even the most informed experts often rely on fragmentary, episodic, approximate or out of date information about other experiences. For some time, a rudimentary systematization of information has

been carried out by the Center for Strategic and International Studies (CSIS), which until 2010 published an annual report on "Government open source policies" and maintained a database of open source policy initiatives worldwide (Lewis 2010). Initiatives are classified by location, administrative level, and four categories: research, mandates, preference, and advisory (see Fig. 8).

Unfortunately this initiative was interrupted in 2010. But it remains an important index of the early spread of initiatives. According to these surveys, the first policies appeared in 2001[12] and in its last version, the database counted a total of 364 open source policy initiatives worldwide, 256 of which were approved.

Since the CSIS stopped collecting data, there has not been any center that has globally and systematically gathered this kind of information. The best available source of information is the Open Source Observatory and Repository (OSOR),[13] an EU-funded information center which seeks to circulate and account for initiatives in the EU. It provides a rich database of news concerning FOSS and public administrations in EU countries and periodically publishes more structured reports (Hillenius, 2018).[14] More recently, GitHub has become a new indirect source of information. Since it is the platform where most FOSS development takes place, some research has recently taken advantage of its concentration of data to analyze the presence of public sector actors on the platform (Feld, 2016). As these data cover exactly the period following 2010, they are especially interesting. And what emerges it is a spectacular growth of activities attributable to public sector actors (see Fig. 9).

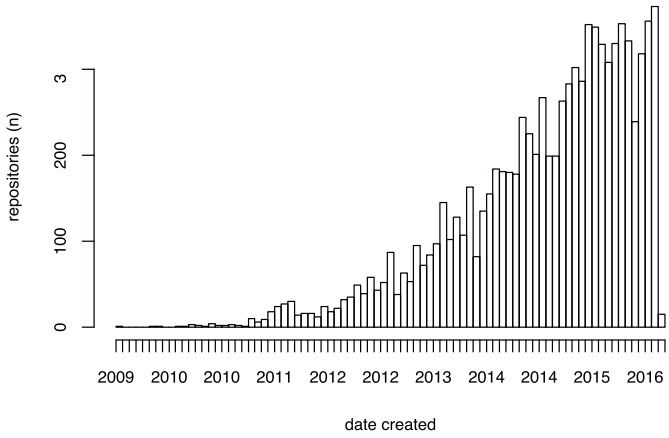


Fig. 9 Repositories created by public sector actors on GitHub. Source: Feld, 2016.

This trend clearly makes the wisdom of the Munich U-turn appear even more questionable, although Munich is not a unique case. Policies supporting FOSS were also overturned in Spain in 2011 and Brazil in 2016, as a result of a change in the political orientation of their governments. But the general trend seems to be the opposite, **worldwide and across the political and geopolitical spectrums**.

12 Prior to 2001, there was almost no policy activity related to open-source software, which could be due to a lack of maturity in open-source software development up until this point and/or difficulty in finding documentation of older open-source policies online.

13 See https://joinup.ec.europa.eu/collection/open-source-observatory-osor

14 See for example, Joinup Open Source Observatory Annual Report (2016) at https://joinup.ec.europa.eu/document/open-source-observatory-annual-report-2016.

CSIS: GOVERNMENT OPEN SOURCE POLICIES

The Center for Strategic and International Studies (CSIS) published a survey on "Government open source policies" for a number of years. Its database was last updated in 2010. It accounted 364 initiatives, at the national, regional, and local level, including initiatives accepted, under consideration, or rejected. They classified the initiatives into four categories: research, mandatory (cases where the use of open source software was required), preference (where preference was given to open source), and advisory (where the use of open source was authorized). Not surprisingly they found a greater propensity for the approval of open-source R&D initiatives relative to mandatory, preference, or advisory policies.

Summary Tables

Table 1

Open Source Initiatives, (2000-2009)				
	Approved	Proposed	Failed	Total
R&D	81	9	2	92
Advisory	70	19	4	93
Preference	78	27	10	115
Mandatory	16	21	17	54
Total	245	76	33	354

Table 2

National and State & Local Totals for all Initiatives		
	National	State and Local
R&D	66	26
Advisory	75	18
Preference	62	53
Mandatory	32	22
Total	235	119
Total Initiatives (354)		

Table 3

Regional Distribution*				
	Approved	Proposed	Failed	Total
Europe	126	27	10	163
Asia	59	20	2	81
Latin America	31	15	11	57
North America	16	11	10	37
Africa	8	1	0	9
Middle East	5	2	0	7

Table 4

Regional Distribution of Approved Initiatives*				
	R&D	Advisory	Preference	Mandatory
Europe	45	37	36	8
Asia	19	16	22	2
Latin America	8	6	12	31
North America	5	8	2	1
Africa	3	1	4	8
Middle East	1	2	2	0

Table 5

Comparison of Approved Initiatives 2001-2009									
	2001	2002	2003	2004	2005	2006	2007	2008	2009
% Advisory	63.6	39.1	24.6	27.7	23.3	20.0	24.0	35.0	25.0
% Preference	18.2	39.1	42.1	29.8	40.0	26.7	20.0	15.0	25.0
% R&D	18.2	21.7	33.3	34.0	36.7	40.0	32.0	35.0	43.8
% Mandatory	0.0	0.0	0.0	8.5	0.0	13.3	24.0	15.0	6.3

*** Regional distribution does not include initiatives from the UN or the OECD. Multinational initiatives were counted for each region represented.**

Fig. 8 Public Initiatives on FOSS 2001-2009. Source: Lewis, 2010.

The data show that before 2001, there was almost no policy activity; that a first jump occurred between 2002 and 2003 (which the report attributes to the maturation of FOSS development, the availability of strong and viable open source alternatives, lobbying efforts by large multinationals invested in open source and the growth of anti-Americanism); and that between 2006 and 2007 there was a second boost (attributed to attempts to escape vendor lock-in and to a reaction to Microsoft's policy of costly software renewal).

4.2 THE REASONS

What leads public administrations and public policy to favor FOSS? Two reasons for the recent growth can be easily identified: the pressure to contain skyrocketing ICT costs in public administrations, and the attempt to emulate the adoption of FOSS by the private sector, especially as a way of reducing costs. But more political reasons have also played a role and continue to do so. From the outset, in other words, the reasons that have driven public policy in favor of FOSS have been twofold: **economic and political**.

In economic terms, FOSS has been presented as a means to **reduce costs** since the beginning, because it has no license fees and it allows for unrestricted reuse, development and modification. Other economic advantages commonly associated with FOSS are that it allows the costs of development and maintenance to be shared, and that it reduces the risk of vendor lock-in that typically makes the cost of switching information systems extremely high. Outside the USA, FOSS has also been regarded as an industrial policy lever aimed at reducing geopolitical and economic dependence on the US software industry and as a base of knowledge and technology on which to build a local industry.

In terms of political objectives, FOSS is believed to guarantee **greater transparency**. The freedom to study and modify software, in principle, ensures both more security and easier control over the algorithms. While geopolitically, it has been regarded as a tool to achieve strategic security and technological independence. For this reason, for example, Edward Snowden's revelations about the pervasive presence of malicious backdoors and surveillance practices in all communication systems have led to a renewed impetus for public policy that favors FOSS.

But experience shows that all these supposed virtues and advantages need to be treated with considerable caution. For example, the costs of switching to FOSS have proved to be much higher than the simple saving on license fees might imply. Other costs—of migrating, training, support and maintenance—can be far more significant. It has therefore become common to rely on the idea of the "total cost of ownership" (TCO), a complicated equation that calculates all aspects, including the risks, associated with a given solution: whether it be proprietary or FOSS.[15]

The belief that FOSS is linked to transparency and so guarantees greater security must also be considered in a more carefully. Programs are often so complicated that inspecting them is only a totally theoretical possibility. Another example of a change in attitude is how the possibility of customization is viewed: it was once enthusiastically celebrated, but is now evaluated with more caution because it can lead to fragmentation, and high costs of maintenance and integration with other systems. Similarly, the expectation that FOSS could facilitate the development of a local software industry or even create a level playing field for small businesses has proved overly simplistic, as a national software industry's strength and ability to compete economically obviously depends on many other factors. It is no coincidence that the heart of FOSS development took place in Silicon Valley, while Brazil, perhaps the country with the most long-term policy in favor of FOSS, has not achieved significant results in this respect. Yet in spite of these and other limitations, these arguments are still the main reasons given to justify public policy in favor of FOSS adoption.

THE PROMISES OF FREE AND OPEN SOURCE SOFTWARE

Reduced costs → no license fee
- shared costs of development, maintenance, use;
- reduced dependence on few or monopolistic providers
- less risk of lock-in
- greater flexibility and possibility for customization

Increased security → unrestricted ability to inspect and correct
- greater transparency in the algorithms
- better protection from malicious backdoors

Democratization of developmental opportunities → the base of knowledge and technology is freely accessible for small business and local industry.

4.3 THE POLICIES: AN OVERVIEW

While these are the advantages in theory, in concrete terms pro-FOSS public policy has ranged from allowing the use of FOSS in public administration, to requiring that public procurement give equal consideration to FOSS alternatives,[16] to policies favoring FOSS solutions over proprietary ones, to attempts to make the use of FOSS mandatory in public administration.

15 The calculation of costs made over time is more sophisticated on paper, but also more esoteric in practice for most officials.

16 Most public procurement today still contains the brand name of proprietary software—Windows above all—resulting in discrimination against FOSS alternatives.

Allowing the **use** of FOSS was often a necessary step in the early years, when public officials regarded it with fear and uncertainty. There were good reasons for these feelings: not only do FOSS licenses offload the responsibility for dealing with malfunctions to users, but the programs were unstable and there were no organizations to guarantee support. Today in many areas the situation has changed. Yet navigating and taking advantage of FOSS programs, assessing the overall costs, the maturity of the programs, and the risks involved in the adoption of a FOSS solution remains complicated. And a lack of internal knowledge combined with a risk-averse attitude in public administration (though not only in public administration) represents a major obstacle for FOSS adoption there.

Publicly funded R&D that publishes its results using FOSS licenses has been the most popular policy from the outset, as it is the easiest for public administrations to adopt, due to its limited implications. Generalizing and making it mandatory to release publicly-funded software as FOSS is a broader objective, which has recently been relaunched in Europe by a campaign by the Free Software Foundation Europe (FSFE).[17] The main rationale behind these policies is that since the software is publicly financed, it should also be made available as a public good (see Fig. 10). A further good reason is to make the results of public funding transparent.

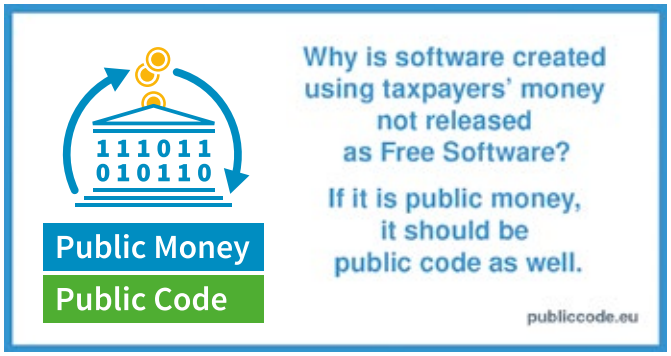


Fig. 10 The Free Software Foundation Europe campaign: Public Money, Public Code.

But the current situation is also often paradoxical. Public administrations spend millions (or even billions) of euros paying private companies to develop specific software for their needs, which other public administrations often have to pay again to use. In many cases public administrations have very similar tasks that can be performed with the same software, but they often end up paying for the production (or simply the installation) of already existing software. To avoid such duplication in the purchase of customized software, in 2016 the federal government of the United States—by far the largest buyer of software in the world—approved a new, two-pronged policy that establishes a kind of double regime. It made it mandatory for code developed for the government to be open to sharing and reuse in all federal agencies; and in addition, it introduced a three-year pilot program requiring federal agencies to release at least 20 percent of any new code they develop as open source. In general, the growth of public entities on GitHub noted above reflects the spread of the attitude of "code in the open" and the practice of releasing customized software developed for a public administration as FOSS, or at least making it potentially reusable by other public administrations. In the UK, for example, public administrations have been encouraged to adopt this practice both to contribute back to the FOSS communities that provide the software they use, and to increase transparency and stimulate reuse and collaboration between public administrations.

Public administrations have installed FOSS programs worldwide. This has primarily been at the server level, where FOSS solutions have quickly become the best, cheapest and most popular. Servers are also managed by ICT professionals, so the users are not ordinary public sector employees.[18] Other kinds of **partial migration** to FOSS programs have been undertaken or announced. The most recent examples are the municipalities of Rome and Barcelona, and the Italian Ministry of Defense. In these cases, the administrations are migrating to FOSS for some applications such as LibreOffice, e-mail management, or web browsers—using applications that are stable, widespread, well-supported, and in some cases dominant in their field—but they maintain Windows as their operating system. In parallel with this, there is some experimenting with splitting up their procurements.[19] For

17 See https://publiccode.eu/

18 FOSS programs are often more difficult for non-expert users than proprietary programs, where the user-friendly aspect is usually much more taken care of.

19 This means that public sector procurement may separate the tender for the operating system (i.e. Windows) from the tender for particular applications (i.e. LibreOffice). In theory, this is supposed to increase the options and the space for alternative solutions.

example, the UK government recommends avoiding large contracts in ICT services. In theory, this should reduce dependence on the usual few big tech companies and facilitate the participation of small local software companies, increase competition and reduce costs. In practice, however, it can be hard for public administrations, with no internal expertise, to manage this approach, and it can also end up being more expensive.

Another policy that is becoming common is stating a **preference** for FOSS solutions in new procurements. For example, in 2019 California approved a law requiring public administrations to develop, purchase or reuse open source software for new IT projects as a first option. India likewise recently passed a law requiring public agencies to choose FOSS solutions and to justify any exceptions. The UK has a similar but less stringent policy. Italy has a long-standing norm of this kind. Yet in both of these latter cases, these norms have not generally been applied in practice. And it remains to be seen whether more recent legislative initiatives will achieve better results.

Non-implementation is also the usual result of the most ambitious policy: the attempt to make the use of FOSS **mandatory** in public administrations or to make a complete switch to FOSS in public software. Various attempts of this kind have been announced at different levels of public administration. At the national level, Australia, for example, had a brief policy of this kind in the early 2000s (it did not even last one year). Several countries in Latin America, such as Peru, Venezuela and Cuba, have announced similar policies at different times. More recently, especially after the Snowden revelations, these kinds of policy announcements began reappearing. Russia re-stated its commitment to taking this approach (and also tried to push for a coalition between the BRIC countries on the matter). China has returned to the project of developing a national Linux-based solution with determination, as part of its long term objective to achieve full technological sovereignty.[20] The EU Parliament approved a resolution recommending that EU structures should completely migrate to FOSS systems, while Bulgaria passed a law in 2016 requiring all government software to be open source.

4.4 LIMITED RESULTS AND BARRIERS TO ADOPTION

Yet so far, most of these programs have not been implemented. Indeed in most cases, whatever the type of policy prescribed or declared, and in even the most sophisticated case—and the UK is probably the reference country in this sense—they have largely remained on paper or have not been successfully implemented. More importantly, while the same arguments continue to be put forward for the supposed advantages of FOSS, in practice no robust model has so far emerged. In general, a number of possible **barriers to FOSS adoption** by organizations—not simply public administrations—have been highlighted. Petrov et al. (2018) provide a recent overview of these potential obstacles (see Fig. 11).

The most important ones are:

- the costs of switching existing systems, including training costs and costs for the recovery of previous data;
- the duplication of systems and costs (in the absence of complete migration);
- other obstacles due to factors linked to the legacy of the past: irrecoverable investments, inertia, habits;
- the resistance of employees and reductions in user productivity;
- a lack of internal support;
- reduced compatibility and interoperability with other software and hardware.

The best illustration of the ineffectiveness of these policies is probably the monopoly that Microsoft has managed to maintain worldwide on desktop and laptop computers with its proprietary Windows.

By analyzing this monopoly we can dig a little deeper into some of the underlying causes that might explain these limited results.

20 More recently the escalation of technological competition with the USA is spreading the urgency and the reach of these independent developments, beginning with the mobile telecommunications. Huawei has already announced that its new operating system, Harmony, will be open source.

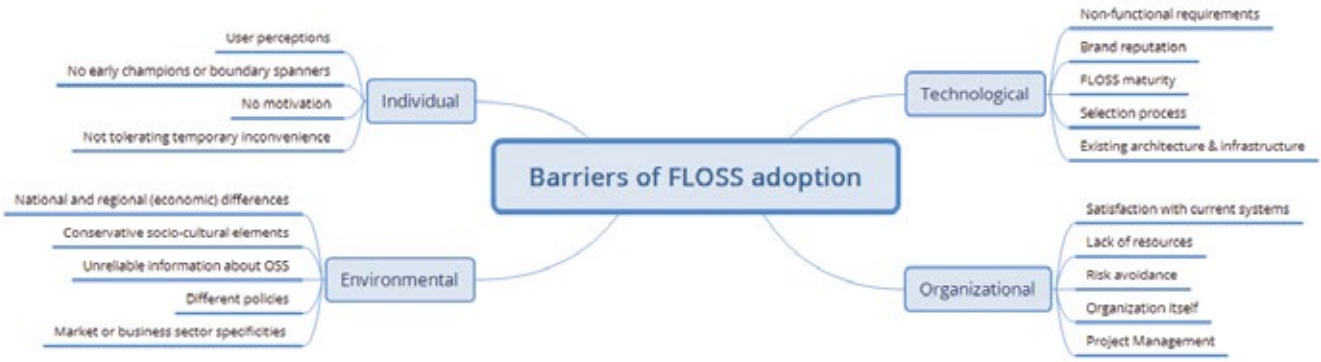


Fig. 11 Barriers to free and open source software adoption. Source: Petrov et al., 2018

5. PATH DEPENDENCE, BREACHES AND THE BREAKTHROUGH

5.1 MICROSOFT: THE INVINCIBLE MONOPOLY

Worldwide, more than **80 percent of personal computers** and desktop computers **use Microsoft Windows**, and in most countries, the percentages are higher in public administration (see Fig. 12). By contrast, the adoption of Linux-based operating systems has never exceeded 3 percent (the remaining share is covered by Apple and Chrome); and, in this case, the percentages in most public administrations are lower.

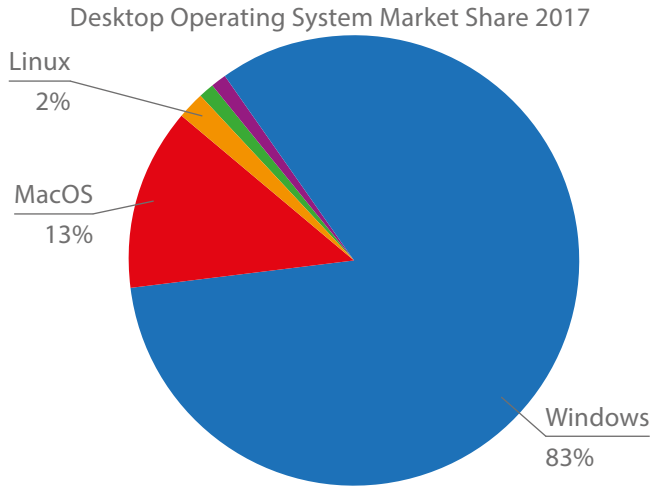


Fig. 12 Linux failure to challenge Microsoft's monopoly in Operating Systems of Personal Computers. Source: https://hackernoon.com/why-the-perfect-os-for-a-software-developer-doesnt-exist-412559314ebd

Microsoft's monopoly must be contrasted with the dozens of governments at all levels—municipal, regional, and national—that have explicitly complained about it in the last few decades, especially when confronted with the discontinuities that Microsoft imposed on its products, forcing the purchase of new versions of its operating system. Added to this are the number of governments that announced their intention, or actually attempted, to free themselves from their dependence on Windows. Israel, the UK, India, Venezuela, South Africa, Cuba and China are just few of the significant examples of national governments that have done so. Cases of cities and local governments doing so are much more numerous.

Yet after Munich, which before abandoning Linux had long been regarded as proof that it is possible to run a large public organization using Linux operating systems, it is now necessary to turn to the French *Gendarmerie* to find another lasting example of a large public organization—running thousands of computers—using an operating system based on Linux. In most cases, in fact, all these announcements of intentions and plans to switch to Linux have at best served as a way to negotiate with Microsoft, to press it to moderate its monopolistic abuses or to negotiate better prices; and in developing countries, it has served to induce Microsoft to soften the intensity of its war on piracy (pirated versions of Windows are not uncommon in the public administrations of poorer countries).

In any case, the lack of effectiveness of these policies is striking. The European Commission (EC) is another emblematic case. In theory, the EC promotes a "standards-based" approach in public procurement and produces norms and recommendations that public administrations should follow to "avoid being locked in to proprietary software". In one recommendation, the EC even attempted to quantify the cost of the actual condition of dependency and lack of competition in ICT procurement as standing at **1.1 billion euros per year** in the EU public sector alone.[21] Yet the EC itself was the first to dodge these rules and recommendations in its own procurement. In 2014, when questioned by Pirate Party MEP Amelia Andersdotter about the EC's procurement practice for desktop operating systems, EC Secretary-General Catherine Day admitted that the Commission was "**in a situation of effective captivity to Microsoft**" and could not avoid renewing its contract. And that doing so without a competitive tendering process (which the EU

21 See European Commission (2013), 'Against lock-in: Building open ICT systems by making better use of standards in public procurement', Retrieved 03/02/2018 at: https://ec.europa.eu/digital-single-market/en/news/against-lock-building-open-ict-systems-making-better-use-standards-public

requires public authorities to do) would have ensured better conditions.[22] As a sort of justification, she added that this captivity was not new or limited to the Commission. Rather, she observed, "the vast majority (98 percent) of public bodies are in a similar situation". This was and remains true. As a result, the EC is apparently preparing to repeat the same procedure for the renewal of the contract planned for 2019.[23]

Behind these failures obviously lies Microsoft's ability to block any challenger's attempt to grow enough to become a serious competitor: its financial levers, its powerful lobby within public administrations, the enormous scale of its operations, its own capabilities and resources, and so on.[24] But simply focusing on Microsoft would not be enough to understand the overall resistance that any potential challenger, or public body looking to switch, has encountered. In fact, the most important barrier that all these attempts have come up against is the entire ecosystem of software and hardware producers that is bound to the Microsoft operating system as a standard platform. Of course, Microsoft has probably exerted pressure and used incentives to prevent cracks from forming in this ecosystem and to keep third-party players loyal to Windows. But even without such pressures, they remained bound to Microsoft for obvious reasons. They had few incentives to adapt their products to the small and extremely fragmented ecosystem of Linux distributions, that never coalesced into a credible alternative pole for the mass producers of desktop computer hardware. There are hundreds of different Linux distributions, and each of them has a multiplicity of versions in circulation (see Fig. 13).[25]

22 See the correspondence between Catherine Day (Secretary-General of the European Commission between 2005 and 2015) and Amelia Andersdotter (Member of the European Parliament 2011–2014) on the EC's procurement practices for desktop operating systems and office productivity suites. Retrieved 04/01/2018 at: https://joinup.ec.europa.eu/document/future-office-automation-environment-next-steps

23 See the documentary "The Microsoft Dilemma: Europe as a Software Colony" (2018), by Harald Schumann and Árpád Bondy, https://www.youtube.com/watch?v=duaYLW7LQvg. Specifically from minute 13.58 to 14.45.

24 To get an idea of the size of a company like Microsoft, consider the fact that, in 2017 alone, Microsoft invested 8 billion US dollars in research into cloud technology, far more than what the EU is struggling to put together for its cumbersome and multi-year European Open Science Cloud (EOSC) project. Or to estimate the capacity it has to block potential competitors, consider its the recent acquisition of GitHub for 7.5 billion US dollars, almost four times the last evaluation the platform received.

25 See the List of Linux distributions, https://en.wikipedia.org/wiki/List_of_Linux_distributions

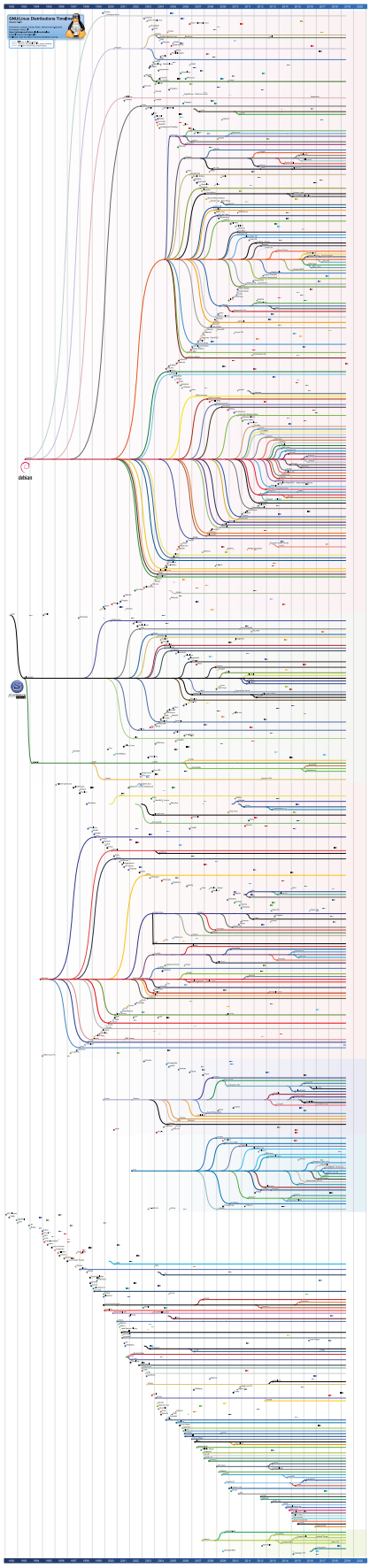


Fig 13 The chaotic fragmentation of Linux Distributions. Source: Wikipedia https://en.wikipedia.org/wiki/List_of_Linux_distributions

This tendency to fragmentation is a likely outcome in FOSS projects, in the absence of a strong leadership that has the capacity to effectively steer and keep a growing community and ecosystem of actors aligned.

Paradoxically, however, public sector actors have contributed to the internal fragmentation endemic to Linux distributions, as particular administrations have tended to develop their own version of Linux in an isolated manner, thus foregoing the primary advantages of adopting FOSS. This is what happened in Spain, for example, where for some time (around 2007–2008) each autonomous community developed its branded, customized Linux version. In hindsight, it seems clear that this **fragmentation** has contributed to the failure of any Linux-based alternative in desktop computers and that one main causes of difficulties in the attempts to migrate to Linux-based solutions has come from the **underestimation of the costs of integration and long-term maintenance** of these systems, which do not exist in isolation but instead need to be continuously updated and adapted to an extremely dynamic hardware and software environment.

Therefore it is not only that individual organizations incur heavy costs for switching from a consolidated system to a new one, because of a lack of internal competencies, employee habits, past investments, migration of past work and data, and so on. Of course each of these barriers poses specific problems. But when taken as a whole, this multiplicity of frictions adds up to a more structural resistance that historians and economists of technology such as Arthur (1989) and David (2007) call **path dependence**. This idea refers to the nearly insurmountable advantage of an incumbent regime, standard or platform, once it has successfully gathered a critical mass of users and an ecosystem of integrated providers of systems, services and products around itself. This, these scholars explain, has little to do with the idea that the most efficient technology prevails. As the famous case of the **QWERTY** keyboard—the still bizarre standard for keyboards[26]—proves, even if it becomes "irrational", it is nearly impossible to topple a standard, especially if this is attempted through uncoordinated decisions or by decentralized cost–benefit calculations (David, 1985). On the one hand, once a platform reaches a critical mass, the creation of a networked ecosys-

26 The system was developed to prevent adjacent keys from jamming on mechanical typewriters, but is still used on devices that have no moving mechanical parts.

tem proceeds to some extent in a "natural" and spontaneous way, through decentralized and distributed efforts. One reason for this is that its adoption starts to generate positive feedback loops, network effects, and positive externalities that benefit all ecosystem actors and act as a magnet for more participants. Escaping this trajectory, by contrast, requires an extra and risky effort. Another reason is that **once a standard or platform is installed, a variety of lock-in mechanisms begin to operate** on many levels. And to successfully diverge from this path requires deliberate collective action, which involves highly complex problems around the coordination of decentralized efforts, and in the short term these would likely mean higher costs, a loss of efficiency, elevated risks and a lot of uncertainty.

In this light, it becomes clearer why the EC has declared itself captive to Microsoft. More generally, these same mechanisms—along with other factors—help to explain the poor results that the EU has achieved with its abstract policies based on principles such as technological neutrality, open standards and competitive public procurement. Moreover, these policies have not prevented the formation of large monopolies, nor have they succeeded in promoting the development of a home-grown software and ICT industry in Europe.

In a nutshell, the attempt to exploit this same logic lies behind what we have called the capitalist strategy of using of FOSS to create an ecosystem. Offering free services on the web is a widely-used strategy that seeks to do much the same thing (Anderson, 2009). Despite the differences, in both cases the main objective is to successfully spread the adoption of a standard, platform, or service, to achieve a critical mass around it, and then to exploit the value co-generated by an entire ecosystem of users, developers and companies, through the selective proprietary control of bottlenecks, adjacent technology levels, side markets, economies of scale or other competitive advantages. Likewise, the great difficulties—and higher costs—of escaping from a consolidated path help to understand why non-economic motivations are often so important in the early stages of many disruptive innovations and experiments, as was the case with FOSS itself (Geels and Schot, 2007);[27] or why in public administration, attempts to migrate to FOSS have tended to persist only in the presence of highly motivated internal staff dedicated to the values of free software.

5.2 THE REVENGE OF FREE AND OPEN SOURCE SOFTWARE

How then has it been possible for FOSS to prevail in the end? The barriers around existing consolidated standards have made FOSS's success much more difficult in the areas already occupied by proprietary solutions (as with Windows in personal computers). **FOSS** has instead **found its way in new areas of development**, at the frontiers of innovation. Web servers, mobile telephones, data centers, the Internet of Things, and cloud computing are examples of areas where FOSS solutions have found it easier to spread. In these areas, FOSS has been able to deploy its advantages as an approach to cheap and distributed experimentation and innovation, with a critical mass of developers and companies coalescing around it.

Other areas where FOSS solutions have most easily prevailed are those **where the end users are mainly developers**, such as in development tools, programming languages, databases, web servers, and lower-level libraries. For developers, in fact, the lack of easy or attractive interfaces or the fact that something is a work in progress (which is often the case in FOSS compared to commercial products) are minor issues, while the freedom to reuse, transform and redistribute software makes a huge difference for them.

Finally, the third element that at some point began to accelerate the reversal of the balance between proprietary software and FOSS was the dynamics of capitalist competition. The **new web companies**—Google, Facebook, Twitter, and Amazon—have given FOSS an important boost, as they have used it to build their massive infrastructure at a very low cost; and also because they learned the importance of feeding communities of developers and third-party applications around their platforms.

27 Similarly, Pérez notes how military and war making expenditures have been important in breaking resistances and barriers posed by cost benefit analyses in previous changes of techno-economic paradigms. Applying political and military criteria, rather than economic logic, allowed for extravagant costs that could not be recovered in the market.

In this way, looking at the state of software production, distribution, and use as a whole, the diffusion of FOSS contributed to a progressive change in the way software is used, consumed, and developed, as well as in the way markets are built around it. Moreover, all these new developments taken together have reduced the importance of desktop computers.

Figure 15. How people access the internet: The shift from desktop to mobile. Source: https://statcounter.com

For Microsoft, the growth of **cloud services** as an alternative to its traditional desktop software has been particularly important. Amazon is a strong leader in this market, which is based on sale of software as a service (the original FOSS commercialization model), and it largely relies on Linux as its operating system.[28] Linux-based platforms are also dominant in the cloud more generally (see Fig. 16). And the need to keep up with this situation was the main reason that led Microsoft to change its attitude towards Linux and FOSS.

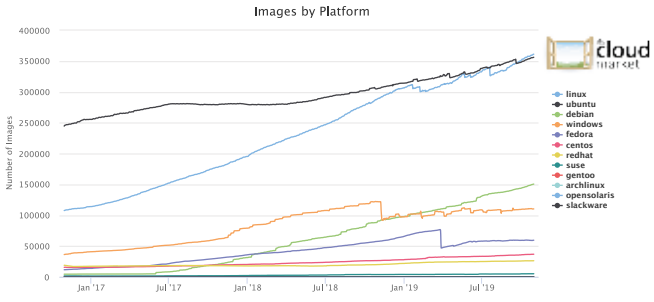


Figure 16 The most popular operating systems on the public cloud.
Source: https://thecloudmarket.com/stats#by_owner

28 More specifically it is Ubuntu, the Linux distribution developed by Canonical, that is the leading platform on the cloud, although other Linux distributions also have important shares. Ubuntu has established partnerships with Amazon, Google and more recently with Microsoft.

At this point, however, a further **breakthrough** is probably occurring at the macro level. As an ecosystem rather than individual solution, FOSS is reaching a turning point: its internal synergies are beginning to overcome and supplant the advantages of proprietary systems, despite the variety of mechanisms that have long been working in favor of the latter in many ways (regulations, past investments, industrial structure, cognitive and behavioral models, technical design, compatibility, etc.). That is, FOSS as a production model and an ecosystem has begun to generate its own "bandwagon effect" (Schumpeter, 1942), with "inclusion-exclusion mechanisms" (Pérez 2003), lock-in, positive externalities, network effects, mega-routines, decentralized alignments, and so forth. This has occurred to the extent that **it is becoming unwise to try to resist to this reversal**, even for the largest and richest software company. And it is obvious that with Microsoft's shift, this reversal of the relative force between FOSS and proprietary systems will only accelerate.

5.3 THE NEW SCENARIO

So here we are. FOSS is winning the battle with proprietary software. There will be, of course, many exceptions, but the trend is unequivocal and no one can ignore it. **Should it be celebrated?** This would not make much sense. Rather, the history of FOSS justifies the **perplexity** that **Ostrom** expressed in the last years of her life when observing the spread of an approach to common goods that she and Hess described as "value-laden" (Hess and Ostrom, 2007). Too many political and economic values have been attributed to free and open source software as such. And these associations have proved too simplistic. It is true that FOSS can potentially lead to greater transparency, cheaper solutions, expanded possibilities for innovation, the possibility of forking, and so forth. But these are all mere possibilities that depend on many other conditions, forces and constraints.

In what directions are its political and economic potentials going to be exploited? Who will reap the benefits? The **answers** to these questions **are not inscribed in FOSS as such**. Nor it is sufficient to look at the concrete arrangements that rule specific FOSS projects (e.g. if they are based on permissive licenses or on the GPL). As we have argued, to understand how these systems work, it is often necessary to enlarge the unit of analysis, to look at the whole ecosystem, and to carefully consider the interaction of different regimes of property and economic exploitation that occur in these multi-layered techno-economic assemblages. Moreover, FOSS has its own vulnerabilities and weaknesses. Its regime of open access poses many challenges on several levels: management, sustainability, asymmetry of power, the appropriation and distribution of value, and the maintenance of coherence and productivity. All of these issues are still insufficiently studied and poorly managed, like the fragmentation of Linux distributions, for example.

In any case, FOSS in itself is no guarantee against misuse and abuse. For example, it is erroneous to assume that open source inherently prevents **centralization or the concentration of power and value** in a few hands. The hefty fine that the EU gave Google for abusing its dominant position in Android speaks for itself. But a reflection on the role that FOSS has played more generally in consolidating the new information paradigm is also needed. The spread of FOSS has not prevented the increasing concentration of power and value that characterizes the current architecture of digital ecosystems and infrastructures. On the contrary, it most likely favored it. This in turn requires a less naive and celebratory approach to open access regimes. Nor should open source be **simplistically** equated with **open standards**, which are often conceived in an equally simplified way as a guarantee of interoperability, data exportability, and reduced lock-in risks. As demonstrated by the fragmentation suffered by Linux distributions, even with FOSS things can easily become complicated regarding compatibility and interoperability. On the other hand, the "compatibilities" imposed by Google on the Android ecosystem show how the development of a FOSS project can be molded to maintain vertical control over large ecosystems.

It is likely that FOSS will come to dominate the way software is developed and consumed. This evolution should not be trivialized, as it means that a new institutional form—a modern commons—is going to regulate society's core functions, infrastructure, and forms of wealth generation in future. But rather than celebrate it as a promise of freedom or democratization, it is essential that public sector actors **do not repeat past mistakes** and **act promptly** if they want to avoid ending up in some new kind of "captivity". This is even more crucial in the case of cloud computing, which is

a market that is already extremely concentrated. Because the very idea of moving public services and public data to the so-called cloud raises a whole new set of issues and implies the radical outsourcing—to a few private companies—of basic public functions and critical data, which has significant implications for autonomy, dependence, security, vulnerability and even sovereignty.

6. A NEW PUBLIC POLICY AGENDA

6.1 NEW TRENDS AND DEVELOPMENTS

Despite the setback of Munich, **public administrations are moving towards FOSS**. There are numerous indications of this trend and, looking at what is happening in the market, it could not be otherwise (see for example, Fig. 17).

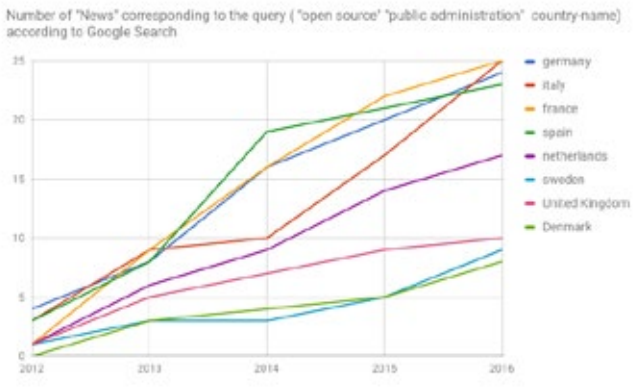


Figure 17 The growth of news about open source and public administration. Source: Leroux, 2017.

Considering the most recent developments, new tendencies can be observed. Reducing costs remains the primary objective of these initiatives: emulating the industry, exploiting the broad availability of open source solutions and reducing the duplication of effort and spending. The latter objective is increasingly pursued by releasing code with a FOSS license.[29] On a micro level, several public administrations have begun **practically engaging** in this open and collaborative development model.[30]

Navigating the ocean of FOSS that is available is becoming an issue. Services to **find, evaluate, and choose** software (according to criteria such as maturity, the existence of an active community supporting its development, legal obligations, security vulnerability, etc.) are in great need and are being developed. Public entities are also beginning to take the initiative. Several have created **portals** aimed at facilitating the identification, sharing and reuse of the software developed for their needs. But portals of this kind often have multiplied—e.g. at the European, national, regional and even municipal level—with each administration creating its own.[31]

Fragmentation within the public sector is actually one of the many paradoxes that can be observed around FOSS, as in ICT generally. Italy, for example, recently carried out a census which revealed that for the country's 22,000 public administrations, 11,000 distinct data centers were in operation, most of which were obsolete.[32] Public administrations—which are supposed to be good at standardizing and homogenizing procedures and solutions—have so far, at all levels, shown less inclination and ability to collaborate and coalesce around common standards or solutions than private companies or dispersed communities of independent developers. A new tendency to **centralize** certain decisions is in part designed to tackle this problem, or at least to provide more coherent national guidelines around digital policy. In some countries, central agencies have been created for this purpose and some of these (such as Italy, the UK, and the USA[33]) have developed specific FOSS policies. These agencies provide guidance and seek to promote a certain level of **standardization of the procedures, solutions, licenses and contractual conditions** for public procurement. Such policy is all the more necessary in a sit-

29 As usual, however, things have proved more complicated than expected. Releasing reusable code is not easy, it has additional costs, and incentives and benefits to take on these greater burdens are not always clear.

30 More sophisticated initiatives—such as the Decidim platform developed by the Barcelona City Council—have dedicated a particular effort to creating communities around their projects, composed of other public administrations and local and international developers.

31 On the other hand, the tendency to host the development on a powerful platform such as GitHub, which was indirectly helping to solve this problem, could become more problematic after its acquisition by Microsoft, which, although the EC hastened to approve it, may become an endemic source of conflicts of interest.

32 25,000 websites, 160,000 databases and 200,000 apps were also surveyed.

33 Brazil and Spain, which were both pioneers with initiatives of this kind in the past, have both seen a similar reversal on the issue, with their relevant agencies being frozen.

uation where many administrations have decision-making autonomy for ICT procurement, but lack the internal expertise required to navigate the complexity of procurement and software offers. Applied to FOSS, such policy is also a way to reduce perceived uncertainties and risks, which are a source of instinctive resistance to its adoption in the bureaucratic culture of public administration. Overall, public policy in this area still appears to be at a very rudimentary stage. And a much bolder, more ambitious and more innovative approach seems necessary to get out of the current manifest inadequacy. The following section outlines three areas for a renewed approach to public policy regarding FOSS.

6.2 GOVERNANCE BY STANDARDIZATION

While governments are struggling to improve internal consistency and to play a more ambitious role in the current digital transformation, state administrations tend to remain on the sidelines of the consolidation processes underway in the FOSS ecosystem and also in the **struggle to define** de facto **global standards** for it. This is actually one of the most important developments underway around FOSS, and it is happening in crucial areas like cloud computing, artificial intelligence, the Internet of Things, and many others (EU 2016).

Significantly, several of these processes are taking place under the aegis of the Linux Foundation, which is becoming a powerful global hub in the tech industry, with all the major companies involved, including top Chinese ones. By contrast, no public sector actor is present.[34] This absence reflects the underestimation of the importance of these processes, but also the neoliberal mindset that still dominates in public policy and that requires public players to maintain a position of technological "neutrality" (assuming that the market will choose the optimal solution). On the contrary, a timely and proactive participation in these standardization processes could be one of the most relevant and effective areas for a renewed form of public intervention.

Standardization is a critical area of governance (OTA 1992; Abbott and Snidal, 2001), but so far it has been rather neglected by public policy. The design, governance and adoption of standards can influence, unleash or hinder the productivity of large ecosystems, and standardization processes can shape the architecture of power in various ways in the complex interdependent production systems that are shaping the global digital economy. They can drive distributed models of innovation and keep them integrated, or they can block them. Dispersal and fragmentation—i.e. a lack of the capacity to steer collaboration, convergence, system integration, and interoperability—are two of the main obstacles to achieving potential productivity leaps in digital and innovation systems, and can also lead to uncertainties that hinder potential adoption, deployment, development and investment (Blind, 2004; EC 2016). Standards also mediate, whether implicitly or explicitly, different forms of generating and appropriating value.

Associating FOSS with standardization may seem like a contradiction in terms, especially for certain approaches that are habituated to celebrating FOSS as a source of unconstrained ("permissionless") innovation. But that is what is happening on many levels in the FOSS ecosystem. At the same time, ongoing standardization is one of the causes and consequences of FOSS's expansion in the heart of the software industry, including the *decommodification* or *commoditization*[35] of some these layers and infrastructures.

Besides, it is a simplification to conceive standardization as a simple obstacle to freedom and innovation. Standards can also unleash innovation (Garcia, 2018). The internet itself—one of the most powerful innovation engines in history—is built upon a handful of common standards and

34 This was the situation when I began this study. However, while reviewing this essay upon its completion, Terence Eden from of the Open Standards division at the UK Government Digital Service told me that the UK government had joined the Linux Foundation in the meantime. While a further important step in the same direction must be considered the Memorandum of Understanding signed in April 2019 between the European Telecommunications Standards Institute (ETSI) and the Linux Foundation aimed at bringing open source and standards closer and at fostering synergies between them.

35 In business literature, "commoditization" refers to a situation where a product becomes standardized and allows for competition based on price only and no longer on unique characteristics or brand identity.

protocols. By establishing common structures and stable building blocks, standards establish hierarchies and layers in the architecture of these complex techno-economic systems. To understand their function, one can think of the logic of platforms. Modern digital platforms provide stable structures or infrastructures (which often maintain a degree of flexibility and openness to innovation even from third parties), but they also create spaces for innovation in other layers or areas (e.g. applications), which are supported, made possible or enhanced by these same common infrastructures. The fact that standards or platforms, when heavily adopted,[36] tend to quickly become *de facto* monopolies (as much as or moreso than the infrastructures of the past) is another reason why public authorities should intervene early in their governance. Yet the need to prevent private monopolies does not diminish the productive role that these monopolies play. On the contrary, these (de jure or de facto) **"monopolies" can be extremely productive and beneficial** (Sidak, 2016). Rather, as happened with the narrow emphasis placed on intellectual property rights, for a long time a simplified vision of innovation has unilaterally privileged aspects of it like unrestrained and unpredictable freedom, while obscuring other factors that are at least as important for technological innovation and for the associated processes of the development and generation of wealth. First and foremost among these are standards, but it also includes all the mechanisms that promote convergence, coordination, stabilization, scale, and interoperability (Blind and Jungmittag, 2008); or, put more simply and more generally: synergy and cooperation.

In any case, it is a mistake to overlook the long term consequences of standardization, which, once brought into force, can stabilize the development trajectories of broad ecosystems that can otherwise easily end up being designed to favor special interests and generate traps, even when based on FOSS. This requires continuous monitoring and early intervention, to avoid repeating past mistakes.[37] Indeed, there are increasing signs of a new awareness of the critical importance of standardization at different levels and in the same EU vision and policies (EC 2016).

6.3 MIXED FORMS OF GOVERNANCE

At the same time, the acceleration, democratization, complexity and unpredictability of innovation are distinctive traits of the present surge of technological innovation. FOSS itself has made an important contribution to promoting these conditions. And its success is likely also due to its greater suitability as an institutional solution in the management of the contradictory requirements—between innovation and cooperation, freedom to operate and ease of reintegration of multiple paths of experimentation, and so on—that mark the new modes of generating public goods, essential infrastructure and structural requirements for information and knowledge production.

The **dynamism, complexity and interdependence of innovation** poses unprecedented challenges in terms of governance. Public administrations may lack the necessary expertise, flexibility, and rapidity, as well the incentives and resources required to provide appropriate governance.

Private standardization mechanisms—whether simply left to market forces or achieved through industry-dominated organizations—have largely prevailed in the last few decades, as a consequence of privatization and deregulation policies and the neoliberal mindset that has dominated public policy. The private sphere has been considered more open to the emergence of and competition between alternative standards, more flexible in rapidly adapting to technical and economic changes and more competent than governments. Yet the private sphere tends to be dominated by the existing asymmetries of power (Garcia, Leickly, and Willey 2005); and large players and first movers tend to reap huge benefits. Outsiders, weaker actors, smaller players are too easily marginalized and cut out. This is all the more true in the digital economy (Crémer, Montjoye and Schweitze 2019). In other cases these private environments may not be able to generate standards due to vested interests, competition, or failures to coordinate and negotiate, which leads to the dead ends and fragmentation that lim-

36 This refers to *de facto* standards, set up by private actors through either standards organizations or market forces; for *de jure* standards, made compulsory, the issue is redundant.

37 So far the only government which has taken steps toward an explicit policy in this regard is the UK government.

it innovation and network economies (Abbott and Snidal, 2001; EC 2016).

Both of these limits are clearly visible in the FOSS ecosystem. But on the other side, the practices that emerged from the hybridism between markets and commons, between communities and economic enterprises have, in some configurations, generated forms of collaboration that have dealt with the dilemmas related to the production of public goods and common infrastructures in innovative ways. To facilitate or at least allow for the flexibility and openness to experimentation that is necessary in governing processes of innovation, public administrations have to develop new attitudes, methods and culture. As has already been suggested, a **"second generation" of public policy** is needed (Voß, Smith and Grin 2009).

Indeed, one of the ingredients of China's leap forward in ICT has been precisely an innovative ability to modulate between decentralized experimentation and centralized standardization in the one policy (EPSC 2019), as well as a flexible blending of planning with market mechanisms (Heilmann, 2009; Heilmann and Shih 2013; Heilmann and Melton 2013; Grillo 2019). In any case, the public sector cannot substitute for or replace the complexity and plurality of actors involved in these processes on its own. Further, in a competitive scene that, at least for the moment, remains essentially global, most states in most cases don't have the scale to aggregate the critical mass required to impose a standard and to foster the growth of an ecosystem of producers around it.

Innovation seems to be required in at least in two directions then: on the one hand, the exploration of innovative ways to **blend** different mechanisms of governance, integrating **state, market and commons based models**; and on the other, new forms of **public-public cooperation**, between different levels of public administration and across national borders. Embryonic attempts to create spaces for sharing experience and collaborating on FOSS policy have indeed begun to emerge at the international level. For example, in 2016, the French government led such an initiative during the Open Government Summit in Paris, which the governments of the United Kingdom, Italy, the United States and Bulgaria responded to and participated in. In another context and with a different agenda, Russia also tried to promote a similar initiative among the BRIC countries. But to date none of these initiatives has thrived.

By participating in such processes, public sector actors could provide new forms of leadership and play a new type of productive role by fulfilling functions that are regarded as generally needed and beneficial. They could help to generate and stabilize standards, which in turn facilitate distributed investment, interoperability, economies of scale, synergies and externalities, systemic productivity, savings and more (Mazzucato 2013b).

We can conceive of these innovations as if public sector actors had to learn to steer coalitions of communities and companies to **generate and administer shared value**. Standardization, in fact, can also be seen as the establishment of a multi-level modulation between a plurality of regimes of access to and ownership, generation and appropriation of value. This is even clearer in the case of "open standards" (especially if they are royalty free[38]), the creation and management of which are in many ways similar to FOSS (although the two must not be confused).[39] Similarities between commons and standards exist in the same mechanisms for generating value or wealth. Most of the value of a standard is in fact based on collective adoption and alignment, and on synergies and externalities.

38 There isn't an agreed definition of an open standard. Wikipedia lists 22 different definitions. In general, an open standard is one that is publicly available. Different definitions emphasize different aspects, including how open the process of defining the standard is to all interested parties, its fairness, and its working according to a consensus-driven process. The main conflict turns on whether patent holders should be allowed or prohibited from charging "fair, reasonable, and non-discriminatory" royalty fees (FRAND) on those who implement and use the standard. The EU has been especially confusing on this matter.

39 Leaving aside the case of open standards that can be made mandatory by a public authority, there are similarities in the processes and outcomes. Of course, as in all types of commons, there are many inequalities in the ability to access and influence the governance of these processes, which are not however simply governed by the logic of hierarchy or markets. But while there are similarities, open source and open standards must not be confused. Independently of the issue of royalties, open standards apply to many more areas, technological and not merely technological.

These cannot be measured by the direct accounting of market-based exchange,[40] which means that they are very badly governed by market mechanisms.[41]

In this sense, an active standardization policy provides a glimpse of the possibility for the public sector to activate **a new kind of "multiplier"**—of its resources and powers—in order to achieve its policy objectives. To an extent, this is exactly what big tech companies have learned to do through their participation in FOSS. But while for private companies the production of a commons is subordinate to and employed in the pursuit of private profit, public sector actors could place the production of the commons at center of their governance goals, while at the same time learning new ways to shape and use both market competition and community-based forms of collaboration.

In principle, public sector actors can facilitate the incorporation of the full range of affected interests, including those of the weaker players, users, and public administrations themselves, in the standardization process. The public sector can help to counterbalance the power asymmetries that exist within FOSS ecosystems. It can prevent the formation of private monopolies or the consolidation of an oligopolistic governance of the FOSS ecosystem. It can help to solve complicated problems of sustainability and governance that often affect the generation and maintenance of these resources, providing services, infrastructure, and alternative mechanisms for recognizing and rewarding value. It can promote social priorities, research axes, political constraints, objectives and values. The General Data Protection Regulation successfully introduced in 2018 by the European Union represents an illustrative example of this possibility (EC 2019).

States can usefully mobilize many levers for such governance, beginning with the simple adoption of FOSS: public administrations are the biggest ICT users and by this measure alone they possess a potentially huge yet untapped influence. But of course they can mobilize all the powers of the state: from public purchases, investment, R&D, education programs, to taxation, regulation, and enforcement (Abbott and Snidal 2001; Garcia, Leickly, and Willey 2005).

For states, the possibility of establishing their rule is only one of the mechanisms at their disposal. And the use of this power should be thought through, leaving adequate space and time for experimentation, competition and pluralism, and to avoid dead ends or sterile paths. But also in these more fluid stages or forms of governance, states should help to develop new mechanisms to monitor these processes and help to define procedural guarantees, rules, and requirements. Generally speaking, learning the respective advantages and strengths of these different governance models based on the state, the market and common goods, and to control and compensate for the relative shortcomings and failures of each, remains an outstanding task. Participation in such environments, which are constitutionally more open, transparent, and less easily manipulated, could also help states to check their own public administrations, which are notoriously subject to capture by parochial or rent-seeking interests.

6.4 DIGITAL (POST-)SOVEREIGNTY

Standards are important mechanisms of governance, which are increasingly used, especially at the international level, to cover much more than mere technological aspects. Standardization should be considered an integral part of the construction and governance of modern infrastructure and even of institutions (Blind and Jungmittag, 2008).

Many of the debates about standards going on today in FOSS involve much more than considerations of mere economic values; after all, the design and management of ICT and software infrastructure are going to directly shape social, political and civil rights, or define critical defense and security issues. These reasons and concerns are starting to lead to public sector involvement in these processes.

Digging deeper, however, an impending "**great digital transformation" of public administration** is looming, and this has barely been addressed and debated so far. As is

40 Increasing interest in the political economy of standards is opening up a new field of research around these issues. See for example, Blind, K. and Jungmittag, A. (2008).

41 The supervisory role played by the Linux Foundation in the industry must be understood in this light: It acts as a guarantor of the fairness of process and of a neutral maintenance of the common resource.

happening to entire industries, it is highly likely that the digital transformation will profoundly transform the way public administration operates: by transforming infrastructure and the methods used to produce and deliver public services, and also by reorganizing the distribution of competencies between the different levels and areas of government. Emerging debates, such as those on "**digital sovereignty**" or on the "**platformization**" of governments, while still vague and nebulous, hint at these more profound implications. The current shift towards relying on cloud computing for services, platforms and infrastructure exemplifies some of the dilemmas that these transformations entail, not only regarding the opposition between public and private (or **outsourcing vs. internalization**), but also regarding the scope and level of the **centralization** and standardization of services and infrastructure.

The huge costs and the complex and conflicting political implications of these transformations are perhaps one of the main barriers to the deployment of any ambitious public policy in ICT: they are discouraging its very conception. They also provide another illustration of the political nature of these processes of technological transformation, including the construction of institutional arrangements that may emerge around the need to govern the FOSS commons on which most critical infrastructure, services and data will rely. FOSS is going to be a protagonist in this transformation and at the same time it allows us to see this transformation in a different light. But the concrete configurations that such critical infrastructure and resources and their management will take cannot simply be derived from the characteristics of FOSS as a commons. Political decisions are going to shape, for example, the scale and degree of commonality—and centralization—of such critical infrastructure and resources. For example, to what extent will these solutions, platforms, and standards be global? How will certain levels of centralization coexist alongside other levels of decentralization, autonomy, and differentiation? The geopolitical tensions surrounding the Chinese construction of the 5G network that threaten to lead to a new digital cold war, calls for data and digital sovereignty, and the requirement of transparency for artificial intelligence algorithms are just a few of the political issues emerging around these new software systems. Yet here as elsewhere the EU's market-centered digital policies seem like little more than a way of hiding and attempting to dodge an outright debate on the implications that these decisions will have in terms of shared and redefined sovereignty.

Whatever scale, and whatever combination of solutions—internal or outsourced, shared or exclusive, global or antagonistic—prevail, the governance and management of these resources and their complex, multi-layered and dynamic **interdependencies** pose challenges that are still very **poorly understood** (Eghbal 2016). The recent Heartbleed case, the discovery of a **vulnerability** in OpenSSL—a FOSS program for secure communications used in web servers by hundreds of thousands of organizations[42]—showed just how fragile things can become when we increasingly, obliviously, and often parasitically rely on FOSS solutions, and it made the whole world tremble. As more and more critical infrastructure is going to depend on FOSS, new solutions must be found to strengthen the sustainability, maintenance, and development of these critical resources. The initiatives to monitor similar vulnerabilities set up in the wake of the Heartbleed case, like those of the Linux Foundation[43] in the FOSS ecosystem or the EU's FOSSA project,[44] seem like small steps compared with the magnitude of the institutional innovations that seem necessary in the FOSS ecosystem.

But on the other hand, such innovations seem to be part of the broader institutional recomposition that the information revolution requires in many aspects of government, at the international, national and local levels. As Carlota Pérez observes, each technological revolution has come up against powerful resistance in the established institutional framework, and the full unfolding of its wealth-creating potential demanded a significant institutional discontinuity: "not only a full revamping of the productive structure but eventually also a transformation of the institutions of governance, of society and even of ideologies and culture, so deep that one can speak about the construction of successive and **different modes of growth** in the history of

42 See https://en.wikipedia.org/wiki/Heartbleed

43 See: https://www.coreinfrastructure.org/

44 See https://ec.europa.eu/info/news/eu-fossa-bug-bounties-full-force-2019-apr-05_en; see also https://joinup.ec.europa.eu/collection/eu-fossa-2

capitalism" (Pérez, 2003). And as Pérez further points out, "this time, the growing share of intangibles in production and trade strengthens the case for interpreting it as a deeper break" (Pérez, 2003).

As an "intangible" that has been growing and taking shape around a different kind of institutionalism, FOSS can rightly be seen as sitting at the center of the current institutional mismatch. And around FOSS, innovative solutions will be tested to deal with this looming institutional discontinuity and recomposition: tested on whether they move in the direction of generating and governing **new global public goods** or whether they will instead develop in the direction of **different coalitions of states competing** to assert their own standards and ecosystems.[45]

45 How the Chinese system will react to the escalation of the US government's technology boycott, especially in mobile telecommunications and 5G infrastructure, could have a major impact on the evolution of FOSS worldwide. China, in fact, could be tempted by a FOSS strategy as a way of assuaging other countries' concerns about security, while attracting a broad ecosystem around its standards; since China could still exploit alternative sources of competitive advantage. A similar possibility could be put forward with regard to the EU, which is facing very different challenges, but which could also emerge from its substantial failure in digital policies through a comprehensive FOSS strategy.

7. CONCLUSION: LOOKING FORWARD

7.1 FOSS AS A LABORATORY FOR FUTURE PUBLIC POLICY

It was difficult to foresee, but FOSS has spread in such a way that it is becoming the hegemonic model of development in the software industry, and it has become an essential ingredient in the workflow of the most successful companies. All the tech companies that have climbed to the top of the stock market indices in the 21st century, displacing the historic corporations that occupied that position throughout the 20th century, have deep roots and broad involvement in FOSS strategies. The most recent example of this would have been unimaginable just a few years ago: Microsoft, which reached top position in market capitalization at the end of 2018, right at the moment it was completing its open source turnaround. This is not a mere coincidence, but an indicator of the deep connections between FOSS and the changes underway in the productive paradigm. An adequate **understanding of and ability to govern** this new model of production, management, and innovation is **still in the making**. But what is clear is that the evolution of FOSS necessitates a thorough reconsideration of the initial approaches to this phenomenon, both the enthusiastic and the dismissive ones.

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FOSS is also the most important manifestation of the rebirth of the commons, which is a broader phenomenon occurring alongside ongoing changes in the techno-economic paradigm. It is the most enlightening case of the **expansion** of the **institutional imaginary**—beyond the traditional dichotomy of the state vs. the market—that the rediscovery of the commons in the last decades has been concerned with (Benkler 2013). It is not by chance that FOSS has inspired innovations in several other domains. Although the trajectory of FOSS is rooted in the specificities of software production and in the evolution of the software industry, it can provide an experimental field and a blueprint for many issues and necessary innovations in several areas of policy and politics: science, knowledge, innovation, technology; infrastructures; geopolitics; and micro- and macro-economics, just to name a few.

Furthermore, it is quite reasonable to expect that **the next area** where new kinds of commons could emerge as innovative arrangements **is data**; that is to say, after software, the second most defining area of the information paradigm.

All these characteristics make clear the importance of progressing in the understanding and ability to govern this new model of production, innovation, management and wealth generation. Dealing with the evolution of FOSS also requires a leap forward in commons studies. We have been suggesting some possibilities in this regard. One of these is to study the new commons not simply as an autonomous domain that is separate from markets and states, but as a phenomenon belonging to a broader transformation of institutional forms: **a new institutionalism** that is evolving —unavoidably— **hybridized with markets and states**.[46] New commons represent new institutions—new forms of property, in the first place—that are contributing to the transformation and reshaping of markets (and eventually also of states), while at the same time being shaped and molded by them.

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The 2018 acquisitions of two of the most important players of the FOSS ecosystem —GitHub and Red Hat—, certifies that FOSS has entered a new phase of deep transformation, internal consolidation and growing centralization. Even so, the ecosystem is still riddled with many tensions and contradictions, many spaces of development are open to its further expansion, and many novelties and innovations will continue to emerge from its evolution.

FOSS is set to regulate the core functions of the future information society. And along with them, new functions, new configurations, balances, alliances and directions are going to emerge from within this ecosystem and through its linkages with the broader world. From this perspective, **one of the most crucial areas of innovation could come from public sector actors**. Public sector actors have para-

46 This hybridism seems equally unavoidable in other kinds of commons in contemporary contexts. See for example Foster and Iaione (2017), who make the same argument with regard to urban commons.

doxically lagged behind the market when it comes to dealing with these novelties. It is not that there has been a lack of public programs to support FOSS projects. It is that no good model has emerged to date. The learning process of public policy in this regard must be considered to still be in its early stages. And it remains to be seen how public sector actors can fruitfully engage with, participate and contribute to the further development of this ecosystem and model of production.

The critical state in which public policy now finds itself is indeed not limited to the experiences accumulated around FOSS. It is perhaps one of the worst legacies of neoliberalism. Yet if in its beginnings FOSS was a laboratory of social innovation and then later a catalyst of market innovation, there are good reasons to think that important experiments and innovations in public policy could emerge around it. Carlota Pérez points out that two legacies in particular—the neoliberal mentality and the national dimension of politics—hinder the ability to think of **new forms of public intervention** that are able to guide the transition from the installation to the deployment of the new techno-economic paradigm and to set the conditions for a new mode of growth.[47] The lack of engagement with the commons could well represent a further blind spot that is responsible for the present impasse.

47 See the box on Carlota Pérez.

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