BROOKINGS

Report

Digital infrastructure is more than just broadband: What the US can learn from Europe's open source technology policy study

Frank Nagle Tuesday, November 9, 2021

Technology and innovation have long been known to be key drivers of growth allowing companies and countries to better compete. The recent U.S. infrastructure bill aims to foster such growth by providing for investments in digital infrastructure. However, these investments are nearly exclusively focused on better and more accessible broadband. Complementary to broadband, open technologies—those for which the underlying intellectual property, whether it is source code or hardware design, is publicly available—are playing an increasingly important role in the modern economy and companies' and countries' ability to innovate. In particular, open source software (OSS) and open source hardware (OSH) have become critical building blocks for both everyday products (cell phones, cars, household appliances, etc.) and cutting-edge emerging technologies (artificial intelligence, big data analytics, etc.). However, since most OSS and OSH is available for free and created through distributed efforts rather than by one particular company, it can be difficult to understand the full economic impact of these critical technologies.

To better understand this problem and work towards a solution, the European Commission, the governing body of the European Union, commissioned a report to measure the importance of OSS and OSH for competitiveness, innovation, and technological independence in the European Union. The full report, for which I was an outside advisor, was released in early September and contains a wealth of information useful for understanding the importance of the open technologies that underly the modern economy. Further, many of these insights can be applied to the United States, although differences between the U.S. and EU environments limit the applicability of some of the report's findings.

On its face, it may seem unwise for any company or country to encourage its employees or citizens to spend time writing code that its competitors can use for free. However, recent research by myself and others has shown that both companies and countries who contribute to OSS and OSH can reap benefits their competitors cannot, including enhanced productivity for companies and an increase in the number of tech startups and employment in tech jobs. This is consistent with the headline finding of the EU report that shows that a one euro investment in OSS and OSH leads to a four euro contribution to total GDP. Therefore, it is important to take a deeper look at the recommendations of the EU report to see how they might be applied in the U.S.

The findings of the EU open source report

Broadly speaking, the report, entitled "The Impact of Open Source Software and Hardware on Technological Independence, Competitiveness, and Innovation in the EU Economy" considers the economic impact of OSS and OSH on the EU along two primary dimensions: supply and demand. On the supply side, it considers the level of investment that EU companies and individuals are making to create OSS and OSH, while on the demand side it considers the impact of the usage of OSS and OSH by EU companies.

The report finds that in 2018 (the last year of data analyzed in the report), EU countries, companies, and citizens invested the equivalent of more than 1 billion Euro in creating OSS and OSH. It further found that the impact on GDP of these investments was between 60 and 95 billion Euro. Based on these numbers, the report shows that if EU policies could increase the contributions to OSS and OSH in the EU by 10%, EU GDP would increase by 0.4%, or 63 billion Euro per year, and there would be an additional 600 information technology startups created per year. Using these numbers to conduct a cost-benefit analysis, the report finds that in the EU, after accounting for hardware and other related costs, for every one Euro invested in OSS and OSH, there is a return of four Euro. In particular, the report finds that small and medium enterprises (SMEs) both invest more and reap more benefits than larger firms. Finally, the report argues that by increasing its support and usage of OSS and OSH, the EU could reduce its reliance on a small group of companies (mostly in the U.S.) for the provision of the bulk of its technology.

To come to these conclusions, the report used a combination of data from a large survey of EU companies and individuals, detailed data on OSS creation and usage from GitHub—currently the largest and most widely used repository for OSS—and a handful of in-depth case studies.

In considering the mechanisms behind how OSS and OSH contribute to the EU economy, the report points out that by their nature, these open technologies provide not only interoperable public infrastructure that generates large positive externalities (much like roads and bridges enable commerce in the physical world) but also a large, freely accessible knowledge pool that enhances existing human capital. In other work, I have pointed out that such positive externalities are critical to solving global-scale problems.

The policy recommendations of the EU open source report and their applicability to the U.S.

As a result of the above analyses, combined with a survey of existing OSS/OSH related governmental policies around the globe, the report offers 13 policy recommendations for the EU. These recommendations are summarized in Table 1 and are grouped into three high-level policy goals:

1. A digitally autonomous public sector (Recommendations 1-3)
2. Open R&D enabling European growth (Recommendations 4-7)

- A digitized and internationally competitive industry (Recommendations 8-13)

These high-level policy goals are aligned with the strategy the EC has set out for itself to guide the EU moving forward.

Table 1: EU Report Policy Recommendations

Rec. #	Policy Aim	Summary	U.S. applicability
I: A digitally autonomous public sector			
1	Building institutional capacity	Although the EU has numerous OSS/OSH related efforts, they are fragmented, and the resulting lack of coordination leads to lower efficiency. Therefore, the report recommends the EC sponsor a handful of Open Source Programme Offices (OSPOs) in various sectors across the economy (public sector, industry, academia, etc.) that would coordinate the OSS/OSH related efforts within and across sectors to increase knowledge flows.	Yes
2	Creation of legitimacy	In an effort to increase the legitimacy of OSS/OSH, the report recommends making it a critical part of existing efforts to boost the EU's technological and digital sovereignty and autonomy. It argues that encouraging the development and hosting of OSS/OSH in the EU could help speed the transition away from the heavy reliance upon technology from the U.S. and other non-EU countries.	Partial – potentially substantial economic implications
3	Strategic intelligence	One long running issue with understanding the economic impact and future of OSS/OSH is limited data on how companies use and contribute to it. Therefore, the report recommends existing EC surveys and studies of innovation, like the Community Innovation Survey, add more questions related to OSS/OSH.	Yes
II: Open R&D enabling European growth			
4	Knowledge creation	Increase R&D funding for OSS and OSH through awards and prizes for both researchers studying OSS and OSH communities as well as the individual communities themselves and SMEs that support the creation of OSS and OSH.	Yes

5	Knowledge diffusion and networking	Sponsor the creation of OSS/OSH platforms and depositories (like the existing EC owned Open Source Observatory) so that the code and the communities can be hosted in the EU (compared to the current situation where most are hosted on U.S.-based platforms like GitHub and GitLab).	No
6	Entrepreneurial activities	Since the report finds that a great deal of OSS/OSH contributions come from SMEs, it recommends that the EC lower various costs for startups to get involved in OSS/OSH, including initiating an awards program and offering SMEs training programs for skills related to managing OSS/OSH projects.	Yes
7	Human capital development	The report recommends the direct sponsorship of various types of OSS/OSH training opportunities (both in traditional academic environments and continuous learning environments) as well as integrating such trainings into existing EU qualifications programs to encourage standardization across countries. Further, the report highlights the gender, racial, and ethnic disparities in OSS/OSH communities and encourages further research to better understand how to address such disparities.	Yes
III: A digitized and internationally competitive industry			
8	Financial capital development	The report suggests three policy levers for developing financial incentives for OSS/OSH development: providing more direct venture capital to SMEs working on OSS/OSH (as well as better publicizing existing government programs for such companies), offering tax incentives to both companies and individuals working on OSS/OSH (including allowing individuals to count their personal time spent on OSS/OSH as a charitable deduction), and altering existing governmental procurement policies to favor OSS/OSH (which my prior research has shown to have multiple positive effects).	Yes

9	Regulatory environment	The report analyzed a number of possible regulatory issues but identified two in particular that are important for the future of OSS/OSH. First, the EC should issue clarifications as to the potential liability for individual contributors to OSS and OSH and, ideally, create legal immunity against liability for them. Second, the report recommends using public funds to finance security audits and related badging and mentoring programs to help reduce the risk associated with using OSS/OSH.	Yes
10	Market creation	The report finds that in many cases, OSS/OSH become de facto standards in various domains but do not follow the formalization process that traditional standards development organizations apply to ensure future companies that build on top of standards are not at a disadvantage compared to those that helped create the standard. Thus, the report recommends implementing such formal rules to allow for enhanced competition, especially in cases where individual companies heavily sponsor a particular piece of OSS or OSH.	Yes
11	Open source hardware specific recommendations	The report recommends increasing consistency across the patent systems in EU member countries towards OSH and related areas including 3D-printing and silicon design in an effort to reduce the uncertainty around which OSH-related activities are patent protected. Additionally, since OSH is in an earlier phase than OSS, the report recommends developing multi-party centers of excellence to both research and promote the development of OSH.	Partial

12	Domain specific recommendations	In addition to broad recommendations related to OSS/OSH, the report identifies a number of domain-specific policy recommendations including having the EC identify OSS as a critical part of its push for greater investment in artificial intelligence (AI), pushing for standards related to high-performance computing that would allow the EU to increase its production of silicon chips, and applying many of the OSS/OSH recommendations to the nascent area of software-defined infrastructure.	Partial
13	Sustainability	The report points out that an increased reliance on OSS/OSH may shift the delineator in the supply chain where products go from commodities to non-commodities. The resultant impact on the environment is unknown, and thus the report encourages the application of funding and incentives to encourage OSS/OSH that provide environmental benefits.	Yes

In many respects, the EU and EU member states are already well ahead of the U.S. federal and state governments in terms of supporting and encouraging the development of the OSS/OSH ecosystem. Despite this, and largely because of the existing technical expertise in the U.S. private sector, there is a great deal of OSS and OSH activity in the U.S. The report found that during 2018, there were more than 260,000 individual contributors to OSS and OSH from Europe, which represented roughly 8% of EU software programmers. Comparatively, using the same methodology, in the U.S. in 2018, there were over 270,000 individual contributors to OSS and OSH, representing roughly 11% of U.S. software programmers. Further, while EU companies and governments have invested over 1 billion euro in OSS/OSH creation, U.S. companies and governments have invested $2.3 billion (or roughly 2 billion euro in 2018).

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Given these differences in starting points between the U.S. and EU, it is safe to assume that some of the report's recommendations may not apply or may apply differently in the U.S. However, many of the recommendations would benefit the U.S. if implemented here. In particular, the U.S. would likely benefit a great deal from implementing recommendations 1, 3, 4, 6 – 10, and 13, although with some minor tweaks.

For example, recommendation 1 encourages the creation of Open Source Program Offices (OSPOs) to better coordinate the existing, but fragmented, OSS/OSH efforts by the government. Although the U.S. could benefit from centralized OSPOs (perhaps one in each state and one in each high-level federal department/agency),

the existing efforts have been limited to harnessing the power of OSS within the government rather than encouraging its development and use across the entire country (e.g., the federal government's primary effort related to OSS—Code.gov, which encourages the use of OSS and the sharing of code across federal agencies—is a good start, but it does not have any mandate for encouraging OSS and OSH use and development throughout the country more broadly).

Likewise, recommendation 8 encourages three financial levers to encourage the development of the OSS/OSH ecosystem: direct government subsidies, tax breaks, and changes to government procurement laws to favor the use of OSS/OSH. Although all three of these can apply in the U.S., it may be difficult to actually get them passed into law. For example, for over a decade, the state of New York has been trying to pass a law that would give individuals who contribute to OSS the ability to write-off up to $200 on their taxes each year, but every year the bill does not make it through committee.

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Some of the recommendations, including those related to helping fund research on OSS and OSH to gather better data and better understand the results have started to be implemented by private actors in the U.S. Organizations like the Sloan and Ford Foundations are actively funding research in these areas, and our joint work between the Laboratory for Innovation Science at Harvard (LISH), the Linux Foundation, and the Open Source Security Foundation is seeking to make more data about OSS publicly available including OSS usage data and developer motivation and financing data. However, a more coordinated effort stemming from the federal government would help to aggregate and speed up these efforts. Projects like the Department of Commerce National Telecommunications and Information Administration's Software Bill of Materials and the Office of Science and Technology Policy's Code.gov (now housed under the General Services Administration) are a good start, but there is much work to be done.

The remaining recommendations, 2, 5, 11, and 12, may be less applicable to the U.S. for a variety of reasons. Recommendation 5 focuses on encouraging the creation of OSS/OSH repository platforms that are hosted in the EU However, most of the largest existing OSS/OSH repositories, including GitHub (now owned by Microsoft) and GitLab, are already headquartered in the U.S. Thus, the end goal of this recommendation has already been achieved in the U.S. Recommendation 11 focuses on unifying patent law towards OSH across EU member countries. Obviously since U.S. states all rely on the U.S. patent system, this is not a problem. However, the recommendation to clarify these laws and create centers of excellence to encourage the research and development of OSH is likely still applicable as OSH efforts are also in the early stages in the

U.S. Recommendation 12 focuses on extending EU efforts in specific domains including AI, high-performance computing, and software-defined infrastructure. Although all of these recommendations may be applicable to the U.S., the existing support of the U.S. government for these areas is quite different than that in the EU, so this recommendation would need adjustments to be tailored to the domains the U.S. is attempting to support.

Finally, recommendation 2 is perhaps the most interesting in terms of its possible impacts on the U.S. economy. Although the high-level goal of creating legitimacy related to OSS/OSH is certainly applicable in the U.S., the manner in which the report recommends going about this would be quite different. In particular, the report recommends making support of OSS/OSH a critical part of existing efforts to boost the EU's technological and digital sovereignty and autonomy and decrease the reliance on non-EU technology. To understand the impact of this recommendation to both the U.S. and the EU, it is helpful to understand the expenditure on software in a global context, particularly the total imports and exports of software between the U.S. and EU. According to data from FactSet, from March 2020 to March 2021, the U.S. exported packaged software with a total value of $343.4 billion, 15.7% (or $53.9 billion) of which went to the EU. Thus, if we take this recommendation to the extreme where the EU gets to a point that it no longer needs to import packaged software from the U.S., there would be a substantial hit to the U.S. economy.

Although the U.S. imports a great deal less of its packaged software from other countries, naturally the question arises as to whether or not the U.S. government supporting the OSS/OSH ecosystem would have a negative impact on U.S. software makers. The bulk of the evidence points to this not being a significant concern. To start with, most U.S. software makers and other IT companies are already contributing to OSS a great deal. Further, if we anticipate a similar 1:4 cost to benefit ratio, found in the EU report, then investments in OSS/OSH are likely to be a force multiplier in the U.S. as well. However, it is quite possible that if the U.S. increases its involvement, it will speed up the development of OSS/OSH to the point where such projects become even more of a de facto standard than they already are. Thus, we may see a shift such that companies are increasingly willing to collaborate on the core technology (operating systems, routing technology, etc.) while competing on the edges (the bells and whistles, services, etc.). Therefore, it is possible that while greater U.S. involvement in OSS/OSH would increase the size of the pie due to the 1:4 cost-benefit ratio, it may also shift the size of the slices of the pie such that developers of core software (e.g., operating systems) may have a smaller slice, while those that develop more specialized software and other technologies building on this software may have a larger slice.

Next Steps:

The EU report on OSS and OSH shines a great deal of light on an area of the global economy that plays an increasingly important role and makes useful recommendations to help nurture the growing OSS and OSH ecosystems in the EU. In many aspects, U.S. policies are well behind the efforts of the EU and its member states to develop this ecosystem in a manner that is both beneficial for the world as well as its own companies and citizens. This is reflected in the recent congressional efforts on digital infrastructure, which

focus on investments in broadband, but largely ignore investments in OSS and OSH. Most of the recommendations in the EU report can be applied in the U.S., and U.S. policymakers should consider making OSS and OSH a more specific part of future policies related to technology, competition, and innovation.

Limited though they are, the existing efforts related to OSS and OSH in the U.S. federal government are a good start and reveal a natural fit for where new efforts (e.g., implementing the policy recommendations discussed above) can be administered. In particular, the National Telecommunications and Information Administration (NTIA) within the Department of Commerce (where the Software Bill of Materials effort is housed) and the Office of Science and Technology Policy (which the Biden administration elevated to a cabinet-level agency) would be natural fits for expanded involvement in OSS and OSH policies. The latter is where the Obama administration's Code.gov efforts sought to harness the power of open technologies for the benefit of the government. Now the Biden administration has an opportunity to pick up where they left off. Whether it be simply by harnessing the 4x return on investment in OSS/OSH found in the EU report or enabling the U.S. to play a critical role in developing the open technology platforms of the future, supporting the critical infrastructure of the digital economy will enable the U.S. to enhance its competitive position as a leader in technology and innovation.

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