THE LINUX FOUNDATION | Research

Measuring the Economic Value of Open Source

A Survey and a Preliminary Analysis

March 2023

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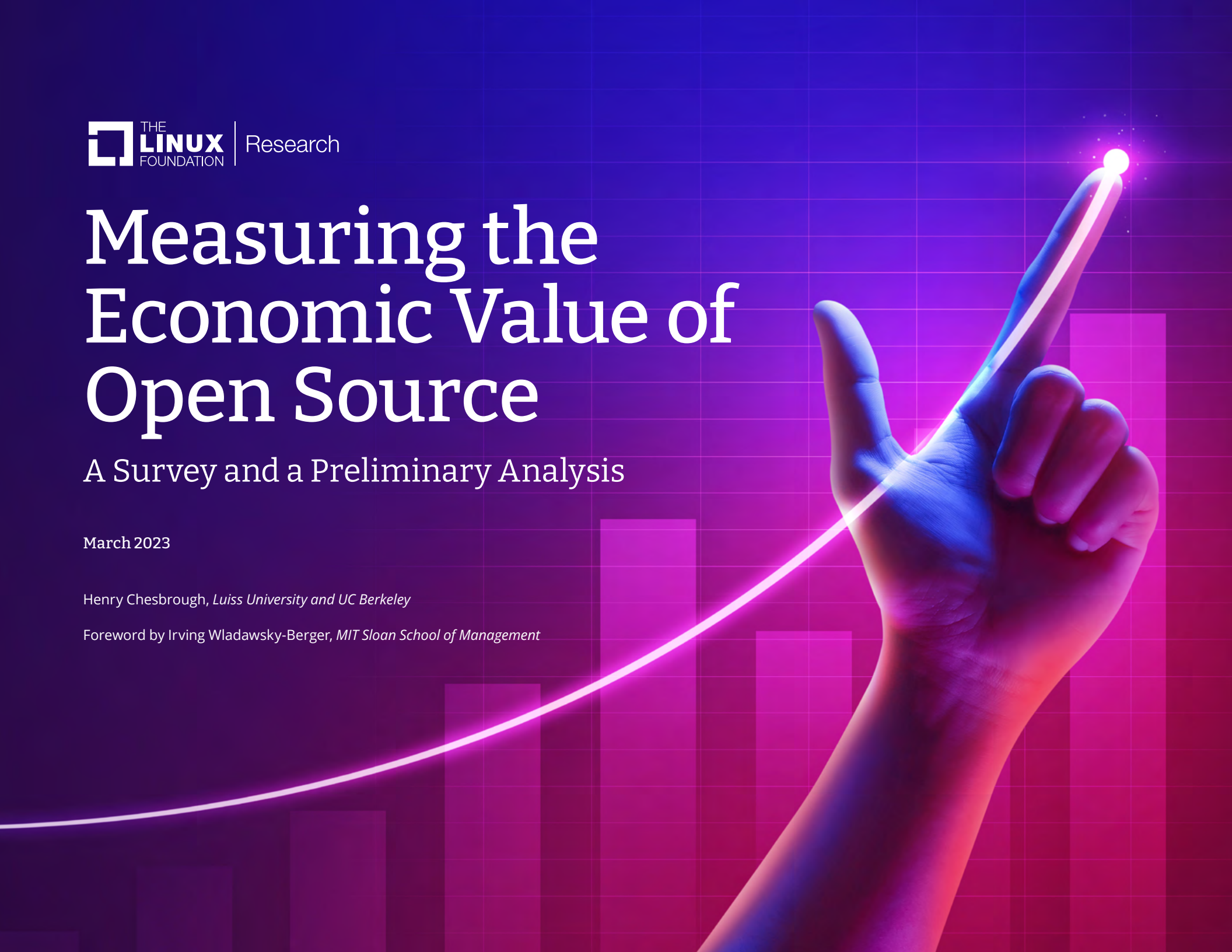

Measuring the Economic Value of Open Source

Respondents rate these benefits of open source the highest:

- **Cost saving**
- **Faster development speed**
- **Open standards and interoperability**

Almost 2/3 of respondents report that **the benefits of open source exceed the costs.**

Most respondents believe **it costs significantly less money to use OSS** than to provide the software functionality themselves.

The ratio of benefits to costs appears to be rising for nearly half of respondents.

The median respondents report that **the economic value of OSS is 1 to 2 times the cost** of its use.

31% of respondents reported that paying for equivalent software functionality **would incur 4X the cost of OSS.**

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Abstract and keywords

Open source technologies, including the ubiquitous Linux operating system, are free to use, and consequently, challenging to value in economic terms. While the reasons for contributors to offer code contributions have been extensively studied, the reasons for using open source, and the value of that use, have received less attention. Professor Henry Chesbrough conducted a survey of open source adoption with support from the Linux Foundation. This White Paper discusses the main results of the survey and what the perceived economic value of open source software (OSS) is to those who responded to the survey. Our sample tilts toward Fortune 500 firms. Results show that open source is, indeed, valuable, not only in itself but also in comparison with alternative technologies that firms could employ instead of open source. Yet its perceived value varies between firms, and it is likely that these differences derive from the practices employed by firms who utilize OSS, particularly whether they have extensive experience with its use, and how actively they contribute to open source initiatives.

Keywords: open source software, Linux foundation, valuation of open source, adoption of open source software

"Software is eating the world."

—MARC ANDREESSEN, CO-FOUNDER AND PARTNER, ANDREESSEN HOROWITZ, 2011

"Most of that software is open source."

—JIM ZEMLIN, EXECUTIVE DIRECTOR, LINUX FOUNDATION, 2022

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Foreword

Once mostly used by research, the Internet, supercomputing, and hacker communities, open source software (OSS) has succeeded beyond our most ambitious expectations. This success is most apparent when looking at the evolution of the Linux Foundation (LF). Initially founded about two decades ago as the Open Source Development Lab by a small number of companies in order to support the continued development of Linux and expand its adoption by mainstream business communities, the LF now has over 1,500 members and is home to hundreds of open source projects, some focused on horizontal technologies and others on industry verticals. According to LF estimates, its sponsored projects have developed over 1 billion lines of open source code that support a significant percentage of the world's mission-critical infrastructures, and the number is significantly higher if we include the contributions of other open source communities, such as the Apache Software Foundation.

While the supply side of OSS has been extensively studied and quantified, we know much less about the demand side, that is, its value to the many institutions that use OSS. Despite the wide adoption of OSS by firms and industries around the world, we don't really understand, nor are we able to quantify, its overall economic value. How did organizations derive benefits, and what were the primary costs of using or contributing to OSS? What's the overall benefit–cost ratio? If not able to use OSS in a project, what would have been the next-best alternatives, and how much would they have cost?

After determining that it was important to get answers to these and other questions, the LF sponsored a study led by UC Berkeley professor Henry Chesbrough—a pioneer in the study of open innovation, having written four books and many articles on the subject. Chesbrough and his collaborators devised and conducted a survey to uncover the reasons that led companies to embrace OSS.

This White Paper explains the methodology used in the survey and discusses its major findings—the highlights are in the body of the paper, and the details are in the Appendix. I found it to be quite interesting, not only because of its findings but because the paper carefully explains how difficult it is to quantify the demand side of open source by asking questions in the survey, where the executives that answered the survey may only have somewhat vague, qualitative answers to the questions you're asking them.

This point highlights that, even though Mark Andreessen's 2011 quip that "software is eating the world" is far more true in 2022 than it was in 2011, we still lack the proper methodologies and tools to quantify the overall impact of software on productivity and on the economy in general. It reminds me that this is also the case with services. As I wrote on my blog a few weeks ago, "Despite being such a large portion of GDP and jobs around the world, the intrinsic nature of services remains vague, hidden from view in plain sight as if they were a kind of dark matter. It's easier to define the services sector by what it doesn't include: it's not agriculture or fishing, and it's not manufacturing, construction, or mining. Just about every other job is in services."

Beyond OSS, something similar seems to be the case with software in general. Despite not just eating but practically devouring the world, the economic value of software is hard to quantify because, like services, its lack of physicality makes it difficult to get concrete, quantitative answers to survey questions.

We hope that you will find the White Paper to be an important step in helping you understand the economic value underlying the growth of open source adoption around the world.

Irving Wladawsky-Berger
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Origins of OSS[1]

The development of OSS goes back to the early days of the computer industry. The OSS movement's roots are in two computing projects in the 1970s and 1980s. Incubated on university campuses, both embodied the "hacker's" ethos of using collaboration to build a better product. The first was UNIX, created initially by AT&T's Bell Labs but then transferred to computer science researchers at the University of California at Berkeley and renamed the Berkeley Software Distribution (BSD) operating system. The second was GNU, the brainchild of Massachusetts Institute of Technology (MIT) programmer Richard Stallman. Both projects were complete operating systems, meaning that they were suites of applications or programs that could operate in concert on a single computer. While BSD was the first truly open source project, GNU was the project that, more than any other, set the rules of the open source game. The intense secrecy with which software-developing companies guarded their often buggy, ineffective products, making it impossible for users to help improve them, galvanized Stallman to create GNU. So, at GNU, Stallman decided to make the project's source code available to everyone. To Stallman, free software entailed four specific freedoms: the freedom to run a program, the freedom to alter it (which required access to its source code), the freedom to make copies of it and either give them away or sell them, and the freedom to disseminate altered versions of the program.[2]

These four freedoms, integral to the identity of GNU, would become standard in the OSS industry. So would the guardrails Stallman set up to govern GNU's developers. As GNU grew, Stallman began to outsource approval discretion over code modifications to a hierarchy of super-developers called "maintainers," so designated based on the frequency and quality of their contributions. Stallman himself sat on top of the pyramid, occupying the role unofficially termed BDFL ("benevolent dictator for life").

Linus Torvalds, the developer who created the Linux kernel in 1992, enjoyed similar BDFL status in the Linux developer community. To make this practice of open collaboration more accessible to business, in February 1998, Christine Peterson coined the term "open source," a term that was quickly adopted by others (Barron, 2018). Linux soon surpassed both BSD Unix and GNU, scaling worldwide, in part because of its embrace by the business community. Other open source projects also took off at this time, and OSS became more and more prevalent in software development projects.[3]

Linux grew to become the innovator's operating system, where users could propose desired features at any time.[4] Developers no longer had to wait for commercial operating systems to (hopefully) roll out new or improved features at a schedule of their choosing. The open and innovative process for Linux kernel development became a methodology for developing and sustaining technologies of many kinds. In the process, a thriving community has come together as a federation of unique open source projects, known as the Linux Foundation (LF). The LF applies its open source governance practices to many other technical areas now, even ones where there is no Linux code involved.

While OSS and open source hardware and standards are free to use, they are not completely free in terms of the total cost of ownership. Users of OSS incur costs to install and maintain the code, and these costs recur whenever a major update or upgrade to the software has occurred. On the supply side, organizations such as the LF spend time, intellectual resources, and other inputs to propose new features and fix bugs in code bases, often volunteering their time to do so. Contributors also produce open source project documentation, implement governance models, manage intellectual property, perform translations, organize community events, and so on.[5]

Previous research on the value of OSS

Research on the management of OSS goes back more than two decades now. The early work of scholars, including Eric von Hippel, Georg von Krogh, Josh Lerner, and Jean Tirole, has helped to shape scholars' understanding of OSS for a generation. These scholars studied the phenomenon of OSS from the perspective of those who contribute code to OSS without receiving monetary compensation for doing so. Much has been learned as a result. Contributors have several motivations for contributing code, including their own direct use of the code (von Hippel, 2005), signaling their coding capability (Lerner and Tirole, 2002), and belonging to a community of practice (von Krogh et al., 2012).

At the same time, OSS as a phenomenon has significantly transcended its modest beginnings in hacker communities and computer science departments (Fitzgerald, 2006). Today, OSS can be found in a myriad of uses, including automotive (Muller-Seitz and Reger, 2010), cybersecurity (Lin et al., 2020), telecommunications (Naudts et al., 2016), making movies, and banking and finance (Dwyer, 2015). It enables startups and small and medium businesses to reduce costs and increase speed to market (European Commission et al., 2021; Gruber and Henkel, 2006). Large companies that contended that OSS was a "cancer" 20 years ago now embrace OSS (Neus and Scherf, 2005; Vitharana et al., 2010). A very recent structured literature review of OSS in the management domain can be found in Cao and Chesbrough (2022).

Most of the research on OSS has taken advantage of the fact that the repositories of OSS are available to the public, including academic scholars. However, if one wishes to measure the economic value of OSS, it is not enough to observe the large and growing number of OSS projects and code commits to those projects. One must also examine how the individual or organization that employed OSS used the software. Yet these actions are not observable to the public. Instead, one must construct ways to probe those actors to uncover the ways in which they use OSS.

Two recent studies have addressed the "demand side" of OSS adoption, both through the use of surveys. One study utilizes a 10-year survey of IT usage from 2000 to 2009, including OSS, and finds a productivity benefit of using OSS (Nagle, 2019). However, this benefit requires that the OSS user possesses complementary capabilities, otherwise the benefit of using OSS is insignificant. A very recent survey of OSS usage within the European Union also found strong evidence of benefits for OSS adoption (European Commission, 2021), with a benefit–cost ratio of 4:1. This result came from a sample where small and medium enterprises were the dominant respondents (75%) to the sample, while large firms were underrepresented in the results.

The survey to measure the economic value of OSS

Many have likened the open source community to a kind of commons, a public resource that is open to all yet different in scope and opportunity from many resource commons because using the resource does not exclude or impair the use of that resource by others. Indeed, if those other users make additional code contributions and help to maintain the code over time, their use may enhance the value of the resource.[6] This White Paper, however, took a survey approach to measuring the private value of using OSS by individual firms, following the work of Nagle (2019) and the recent study by the European Commission (2021). The use of a survey ascertained the costs and benefits of OSS to individual organizations as they develop software for projects. This approach overlooks the societal benefits of OSS and is therefore a more conservative approach to estimating the value of OSS in comparison with the nature pricing methodology employed by environmental advocates.

The benefit of this survey approach, though, is that it is mostly individual people and organizations who make decisions with regard to the use of OSS as they develop projects. The decision of whether and when to employ OSS hinges on organizations' perceived private benefits and costs, excluding societal benefits. Hence, findings from this survey should be directly relevant to those individuals and organizations seeking to develop software for new project activities. By contrast, policymakers evaluating whether and how much to support OSS might want to consider a method that explicitly incorporates societal benefits into the question of its value.

We sought to measure the perceived value of OSS in two ways in the survey:

- First, we probed the costs and the benefits of OSS in general within that organization as perceived by the respondent. We offered several prompts for possible costs and several prompts for possible benefits. We further allowed respondents to write in additional cost or benefit attributes that the survey might have overlooked. We then asked how rapidly the costs were growing over time, how rapidly the benefits were growing over time, and how the ratio of costs to benefits was changing over time.
- Second, we asked respondents to think of a major project that had recently been completed that included OSS. For that specific project, we inquired about what the alternative approach to achieving the project would have been absent the ability to use OSS and what that would have cost.

We made the choice to focus part of the survey on a recently completed project to provide a more robust grounding for answering a series of rather detailed questions. By asking for such a project, we followed the methodology utilized recently by Cohen et al. (2019) in their empirical survey of innovation activities. This approach assumes that the respondent will provide more reliable estimates for a specific project than they would for the organization overall. It further assumes that the project selected is representative of projects underway within the organization.

Given the limitations of probing respondents' perceptions of costs and benefits, we also chose to triangulate the respondents' estimates by probing three aspects of valuing OSS in use. First, we wanted to ascertain the cost of using OSS and set that as the baseline for what follows. Second, we wanted to examine the best available alternative solution if OSS was not available. Usually, this was a commercial piece of software, which would include installation, service, and support over time. And third, we wanted to know what it would have cost to build the solution internally instead, keeping in mind that this internal code would also require installing, servicing, and updating over time. Asking about costs and benefits through these three alternate

perspectives aims to broaden the respondents' consideration of value and establishes a range of value estimates from those respondents.

The survey and its responses are available in full in the Appendix to this White Paper. The survey starts with contextual information about the respondent and his/her role within the organization along with demographic information about that organization. To elicit information about the value of OSS, we chose to probe both the perceived costs *and* the perceived benefits of OSS. We were careful to make the scales for the respondents' answers completely neutral so that we did not prejudge their answers.

We pretested the survey with members of the Linux Foundation Research Advisory Board. This allowed us to clarify the phrasing of our questions and ensure that the responses received were consistent with the objectives of the survey. Even in this pretest group, who are highly engaged in OSS projects and activities, there were certain questions that some of our respondents did not know how to answer. This was particularly true for questions regarding the size of the code base for a specific project and what proportion of that code base was built from OSS. This pattern was also observed later in our larger sample.

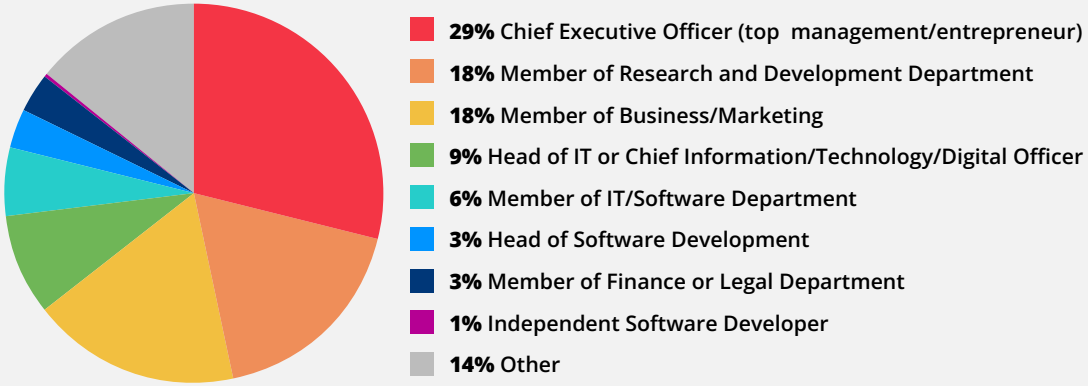
Constructing the survey sample

Early in this project, we were fortunate enough to receive a briefing from the research team that organized a survey of OSS adoption in the E.U. (European Commission, 2021). One surprising finding from that work was that most of the survey respondents were small and medium enterprises (SMEs). Because that survey had covered well the responses of SMEs to open source, we chose to focus this survey and its survey sample on larger companies.[7]

To that end, we purchased a list of the CIOs and IT managers of Fortune 500 companies in the U.S. We supplemented that list with companies already engaged with the Linux Foundation as well as companies who belonged to the industry group called the Berkeley Innovation Forum. Finally, the individual contacts on the author's LinkedIn page were also added to the sample. Because of this sampling approach, we cannot claim that our survey sample is statistically representative of the Fortune 500. However, we were able to obtain 439 usable responses to the survey, so the sample does include many, if not most, of the Fortune 500. However, the number of usable responses to some of the survey questions was more limited, as some respondents stated that they lacked the specific knowledge needed to answer those questions. This became particularly acute for the section of the survey regarding the specific number of lines of code used in a recent, major product or service development initiative. As noted above, this was also observed in the pretest of the questionnaire.

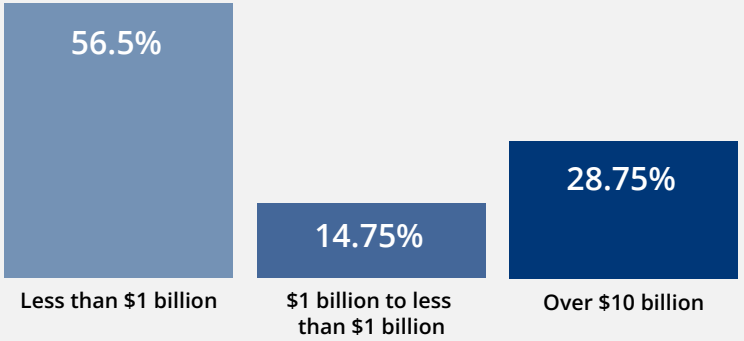
QUESTION 1

Please indicate your position or responsibility in your organization.



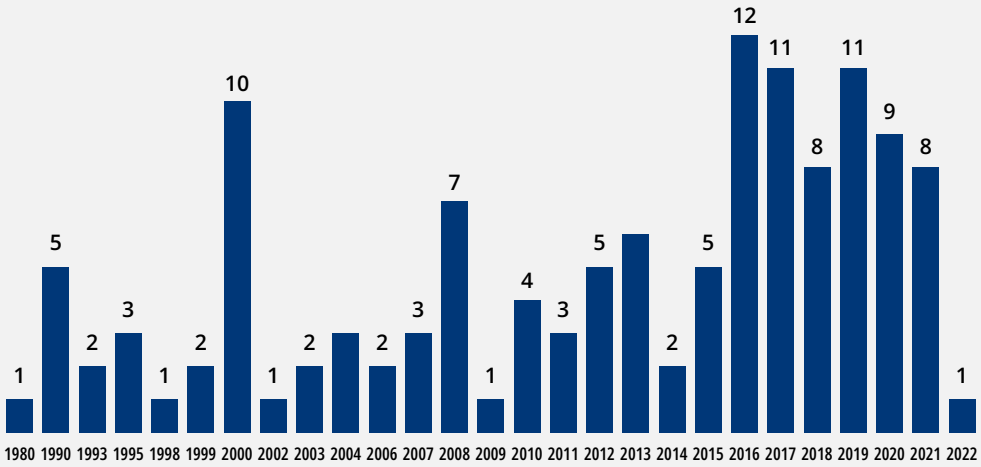
QUESTION 3

2021 Total annual revenue (USD) with goods and services



QUESTION 12

In what year did your organization begin to work with OSS?



Top-line survey results

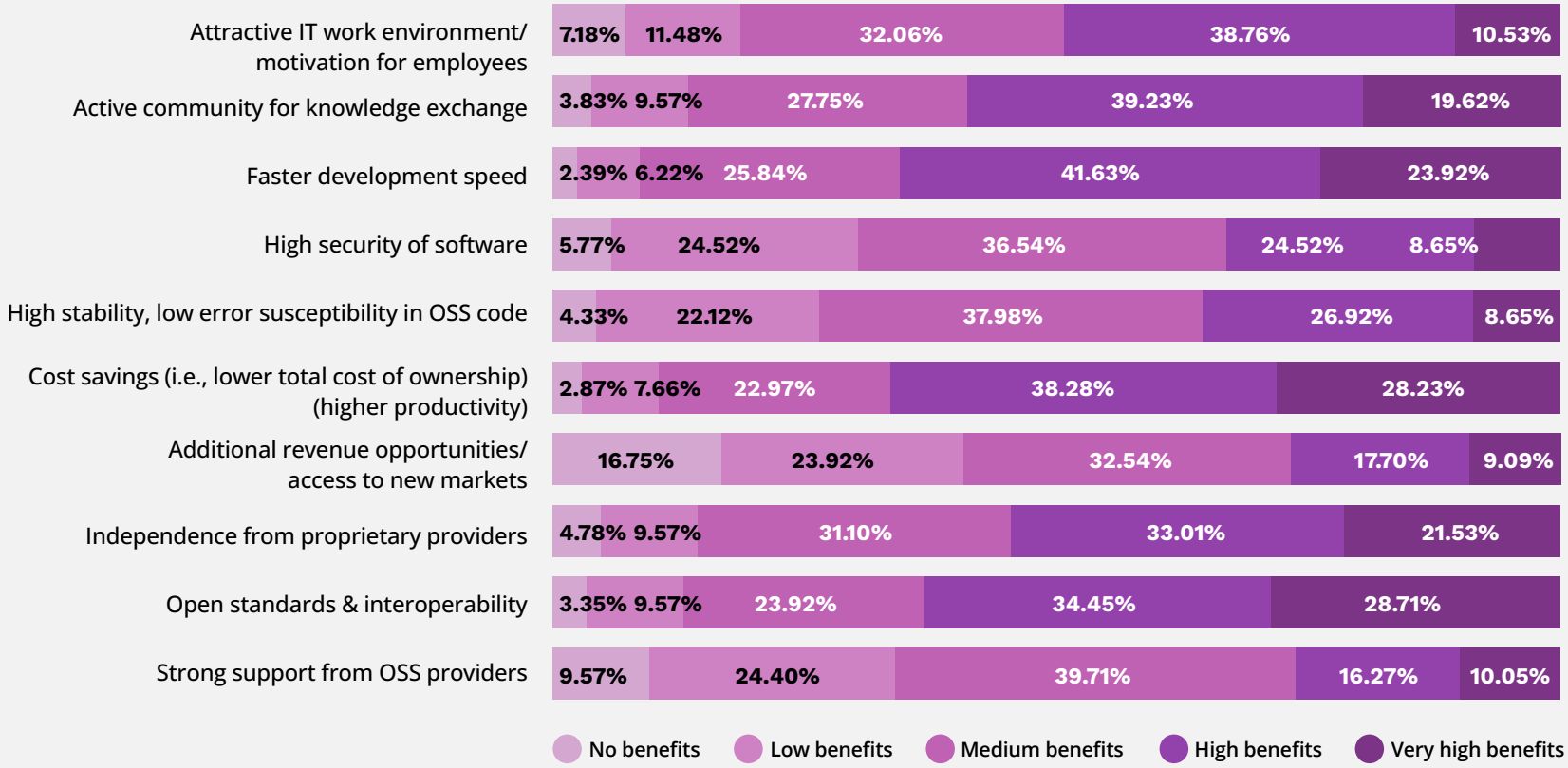
The complete survey results can be found in the Appendix to this White Paper. What follows below is a selected subset of the results, chosen to highlight findings of particular interest.

Our sample frame targeted CEOs and CTO/CIOs of Fortune 500 companies. The response to our survey shows that 38% of our 431 respondents held these roles. In other cases, though, it is likely that the initial person in our sample passed the survey on to another person in the organization, with members of R&D and Business/Marketing departments being the most frequent respondents.

Our sample frame aimed to target Fortune 500 organizations. The response to Question 3 shows that this occurred often, though not always. Almost half (43%) of the responses came from organizations with revenues exceeding $1 billion, but the majority of responses came from organizations with revenues of less than $1 billion. In 2022, qualification for the Fortune 500 required

QUESTION 16

Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:



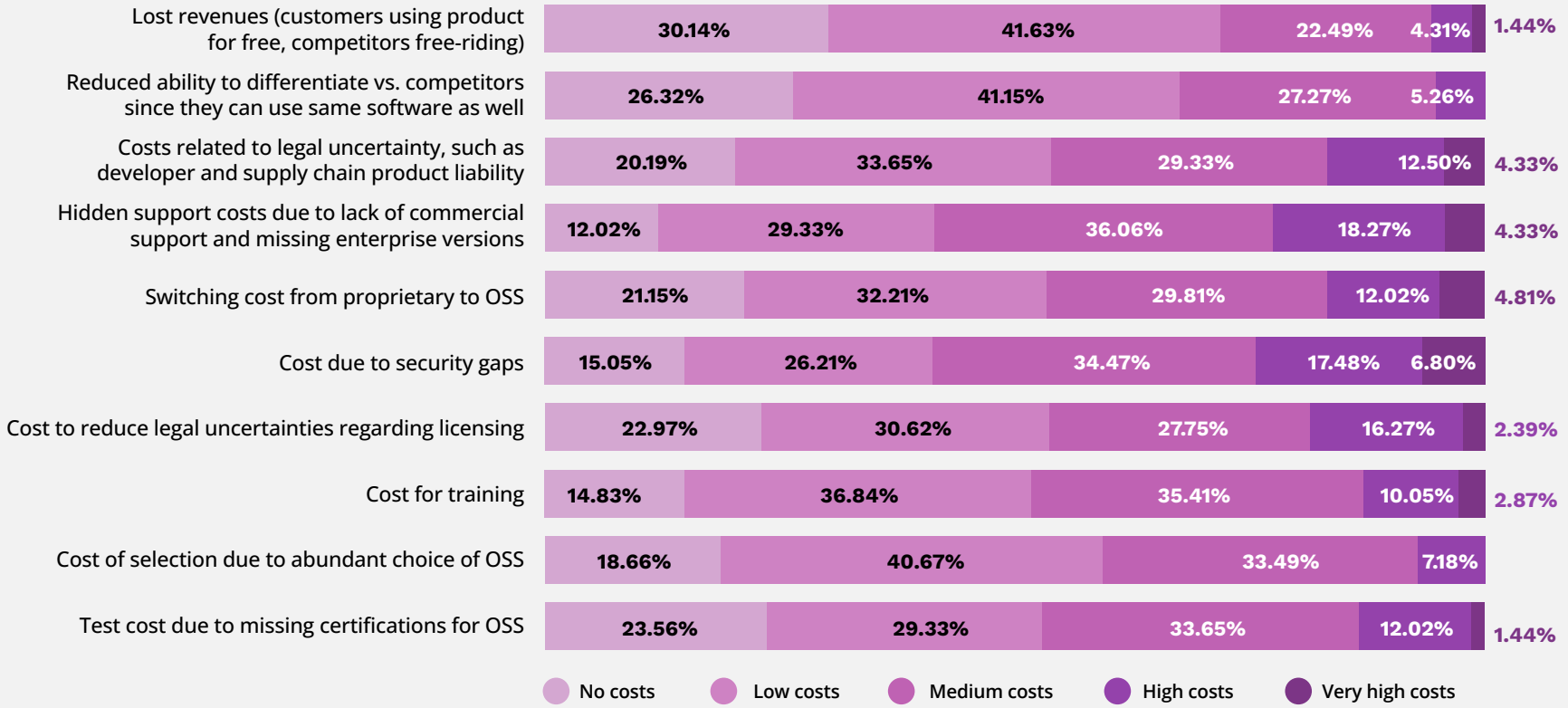
revenues above $6 billion, so our responses clearly included organizations that did not fall into this category.

Many of the organizations in our sample have been working with OSS for more than 20 years. However, a significant number have only started working with OSS in the last five years. Our sample thus included firms with significant variation in their experience with OSS. This variation likely accounts for some of the differences in the perceived value of OSS within our sample. In a follow-on question (Question 14), 19% of respondents had instituted an Open Source Program Office (OSPO) to help coordinate the use of OSS and compliance with OSS licensing parameters, while 81% had not created an OSPO.

We gave respondents several prompts to the question about the possible benefits of using OSS and a five-point scale to rate each

QUESTION 17

Based on your experience, rate the primary costs associated with the use of or contribution to OSS for your organization for each of the following:



possible benefit. If we restrict our attention to the top two ratings (high benefits and very high benefits), the most highly rated benefits in rank order were:

- Cost savings
- Faster development speed
- Open standards and interoperability

Respondents were also given several prompts to the question of the possible costs of using OSS and a five-point scale to rank each possible cost. Restricting attention to the top two ratings (high costs and very high costs), the greatest perceived costs of using OSS were:

- Security gaps
- Hidden support costs
- Reducing legal uncertainties regarding licensing

Having queried respondents on both the perceived benefits of OSS and the perceived costs, we asked them to assess the

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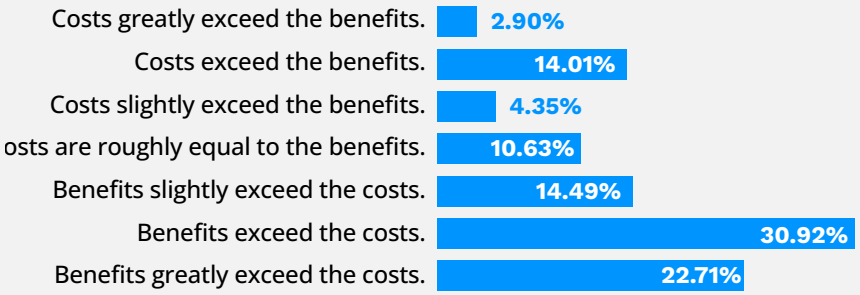
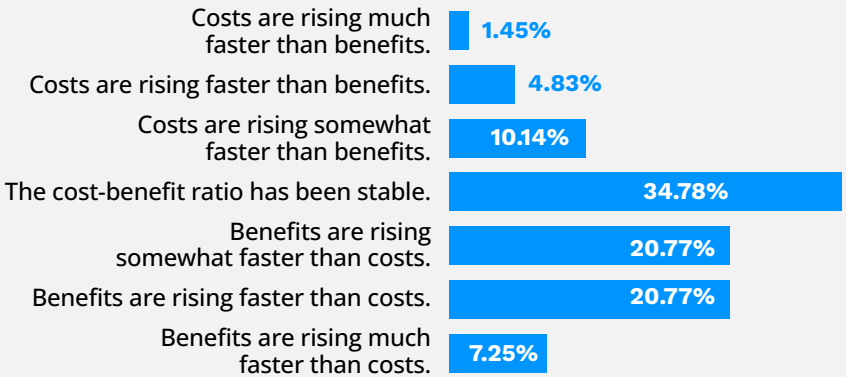
QUESTION 18

What is your assessment of the overall benefit-cost ratio of using or contributing to OSS?



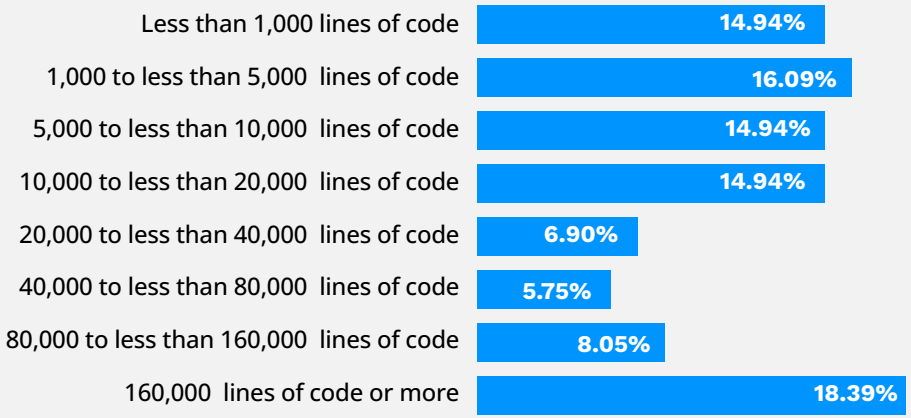
QUESTION 19

How is the overall benefit-cost ratio of using or contributing to OSS trending in your organization over the past 5 years?



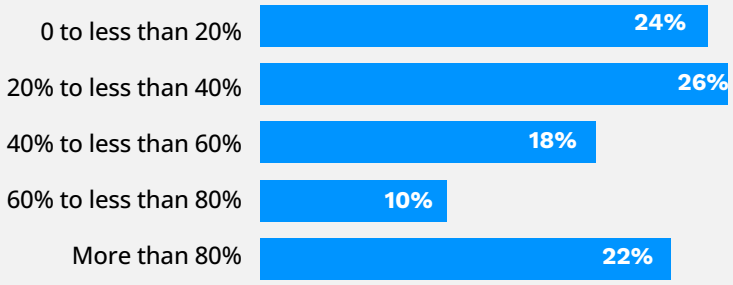
QUESTION 22

Approximately how many lines of software code were included in this new offering?



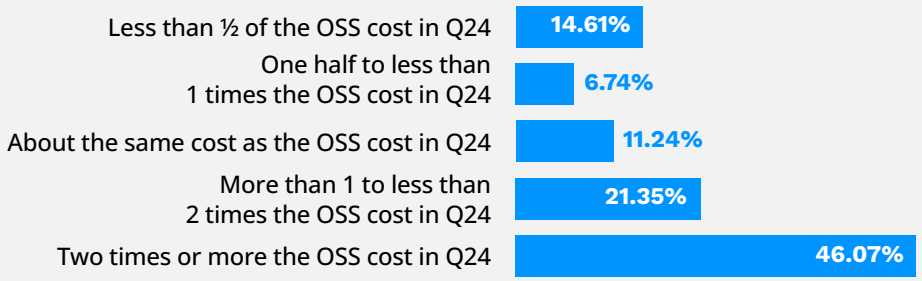
QUESTION 23

Approximately what percentage of those lines of code were created from OSS?



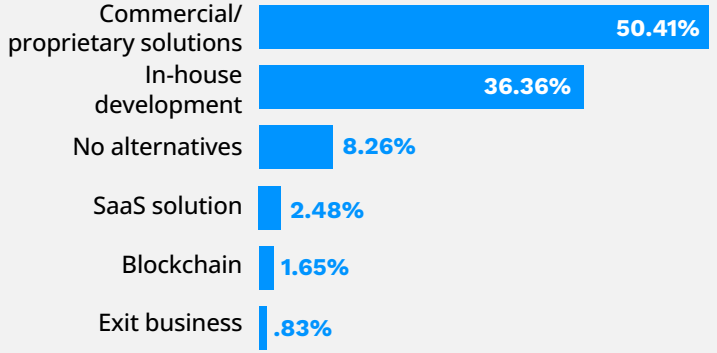
QUESTION 25

For those OSS lines of code: How much would it have cost you to write the necessary lines of code to achieve that functionality with your own software, rather than with OSS software, including ongoing support and maintenance of the code?



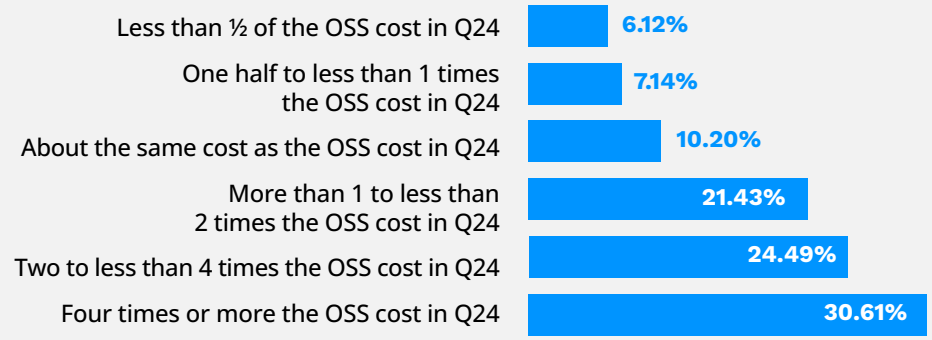
QUESTION 26

If you had not been able to use OSS in this project: What was your next-best alternative to achieve a similar level of functionality in your release?



QUESTION 28

Q28: If you had to purchase this level of software functionality in the market (from another software company, developer, or consultant): What would you likely have paid to obtain that functionality, including ongoing support and maintenance of this code from the market?



benefit–cost ratio of OSS in their organization. Almost two-thirds of them reported that the benefits exceeded the costs, and only one-fifth reported that the perceived costs exceeded the benefits.

We then asked how the benefit–cost ratio is trending in their organization. About half of the respondents reported that the ratio had been improving over the past five years. Only 16% reported a decline in the benefit–cost ratio over that time frame.

For the next set of results, we asked respondents to identify a recent new product or service and use that project to answer the questions about the possible alternatives to using OSS in the project.

This question demanded a lot of knowledge from our respondents, and we received far fewer responses to this and subsequent questions as a result. The number of lines of code in the chosen project varied greatly across our respondents, from rather small projects with less than 1,000 lines of code to massive projects with more than 160,000 lines of code.

Respondents also varied in what percentage of the software in the chosen project comprised OSS code. The respondents were more or less evenly distributed between 0–20%, 20 to 40%, 40 to 60%, 60 to 80%, and 80 to 100%.

Respondents' answers showed that most (67%) believed that it would have cost significantly more money to provide the software functionality by writing their own code relative to using OSS. Only 21% believed that it would have cost less to write their own code for that functionality.

In this question, we sought to identify the best alternatives to using OSS. Unsurprisingly, commercial code and in-house development were the primary alternatives to using OSS.

Given these alternatives, most respondents (75%) felt that it would have been more expensive to purchase commercial code as the next-best alternative to OSS. Only 13% felt that it would have been less expensive.

Analysis of survey results and discussion

We designed this survey to elicit careful consideration of both costs and benefits of OSS in Fortune 500 companies. As noted earlier, this sample skews more toward these large companies in contrast to the sample reported in the earlier E.U. survey on OSS (2021). Part of the survey sought to drill down to specific projects and the code base of those projects to estimate what alternatives the respondents could have used in place of OSS in building their code.[8] The questions also encouraged respondents to consider the total cost of ownership for OSS, beyond the acquisition of the initial code, to include installation and ongoing support and maintenance costs for the software.

Considering the various questions and their respective responses, it is quite clear that respondents perceive OSS to have substantial economic value. The perceived benefits clearly exceed the perceived costs for a strong majority of respondents—60 to 75%, depending on the specific question. And the ratio of benefits to costs appears to be rising for nearly half of the respondents, while only 16% felt that the ratio was declining. This strongly suggests that the value of OSS will increase even further in the future for most participating organizations.

According to the median responding organization to this survey, the economic value of OSS is 1 to 2 times the cost of its use. And this median result hides an asymmetric disparity at the ends of the spectrum of costs and benefits. Very few respondents (3%) saw costs well in excess of the benefits of OSS. On the other hand, 22% of respondents saw value that greatly exceeded the cost of using OSS. This asymmetry continues for most of the responses to this survey, where the highly positive end of the spectrum of results is much more often reported relative to the highly negative end of the spectrum.

Moving to a specific project, we can be a little more precise about quantifying this asymmetric result.[9] For the focal project identified for the survey, 14% of respondents judged building the code internally to be less than half of the cost of using OSS. By contrast, 46% of respondents felt that building the code internally would have cost two times the cost of using OSS or more. The other main alternative to using OSS in the focal project would have been to buy commercial software instead, and the results are again quite asymmetric. Only 6% judged that commercial software would have cost less than half the cost of using OSS. On the other end, 30% of

respondents determined that commercial software would have cost four times as much as the cost of using OSS, and another 25% felt that the commercial software would have cost at least twice as much.

There is additional value in OSS beyond these results, even in some of the cases where its costs seem to exceed those of internal development. In the pretest phase, some respondents indicated to the author that OSS might cost a bit more than internal development, but they still chose to utilize OSS because it was available now, whereas internal development would require some time in order to complete, and the internal software group may have lacked the staffing capacity to undertake that project in the immediate future. Indeed, the faster development time was the second-most cited benefit of using OSS in the survey.

It is noteworthy that not all respondents saw OSS's value exceeding its costs. Another reason for this disparity, in addition to the lack of staffing capacity noted above, could be that some organizations have only recently started using OSS and may be incurring startup costs with adopting OSS that have not yet been covered by the benefits received from OSS so far. One of the leading perceived costs of the use of OSS among respondents is the management of licensing requirements, and changing this likely requires internal processes in order to track this effectively. Only a small percentage of respondents have formally created an OSPO, which can centralize the management of these requirements. A recent study of OSPOs by the LF (Linux Foundation, 2022) also found that these offices help to disseminate best practices in working with OSS across the organization. This is in contrast to situations where individual projects in different departments within an organization engage with OSS in their own, ad hoc, ways.

Another aspect of OSS's economic value to responding organizations lies in the extent to which companies allow their own staff to contribute code to OSS projects. There is evidence that the more an organization contributes to OSS, the more they benefit from it (von Krogh et al., 2012).[10] This result likely also increases with experience in using OSS, so organizations that have only recently started to use OSS may have yet to discover its full potential to help shape the surrounding environment for the organization and steer the technical direction of critical technology that the organization is building and relying upon (West and Gallagher, 2006; Alexy et al., 2018). This survey does not capture these strategic benefits of participation in OSS projects, providing another reason why the results reported here, though highly favorable to OSS, may actually underestimate its value to participating organizations. And, as noted above, these results also do not take the societal benefits of OSS into account. Society benefits from the ability of other firms to access the same OSS repositories, something that an individual firm may not value and that our survey did not measure. And the availability of these open repositories may even enable new firms to enter who otherwise might not have, a further societal benefit not captured in this survey. So, from a social perspective, the value of OSS adoption is even greater than the results reported here.

Conclusion

OSS has come a long way from its roots in the computer hacker community. Today, it is a valuable resource for organizations of all sizes, be they startups, SMEs, or Fortune 500 organizations. There are several costs to be aware of in the decision to use OSS, from installation and support costs to licensing compliance requirements and potential security gaps.[11] However, the results of this survey are quite consistent with earlier survey research (Nagle, 2019; European Commission, 2021), which shows that the perceived benefits of utilizing OSS significantly exceed these costs for the large majority of organizations that use OSS.

OSS provides several important perceived benefits, including lower cost of development of software code, faster deployment of code, and the freedom that comes from adhering to widely shared technical standards. As noted above, some organizations also are learning to use OSS strategically, to shape the environment for the organization in ways that are more favorable to that organization. It is also likely that greater experience with using OSS will further enhance these benefits. This means that organizations that have not yet adopted OSS should look beyond the initial startup costs associated with adoption to a longer-term perspective in which the organization learns how to benefit more effectively from OSS. Indeed, some organizations adopt OSS even when its costs seem to be higher than alternatives because of the improvements in the speed of creating and deploying the code.

A final thought for those organizations who have not yet adopted OSS is to remember one of the insights from the very early days of OSS: It pays to be more open. Software is a technology whose importance is steadily increasing over time. Opening up one's process for developing this foundational technology in your organization can enlist the voluntary contributions of many, many other talented and creative developers. There is value in unleashing this cognitive diversity on your behalf. There is an option value from enlisting these external contributors, where you cannot know in advance what they will contribute, but there are good reasons to expect very positive contributions, well beyond what your internal software resources would likely have generated. Adopting OSS can allow you to embrace a more vibrant, surprising, and exciting future.

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Appendix

Section A: Position of the person answering the questionnaire

Q1. Please indicate your position or responsibility in your organization.	Count	Percentage
Chief Executive Officer (top management/entrepreneur)	125	29.00%
Head of IT or Chief Information/Technology/Digital Officer	38	8.82%
Head of Software Development	14	3.25%
Member of IT/Software Department	25	5.80%
Member of Business/Marketing	76	17.63%
Member of Finance or Legal Department	14	3.25%
Member of Research and Development Department	77	17.87%
Independent Software Developer	2	0.46%
Other	60	13.92%
Total	431	100.00%

Section B: Basic information about your organization

Q2. What is your organization's core business or primary sector of activity?	Count	Percentage
Agriculture	2	0.46%
Automotive	21	4.87%
Business Services	30	6.96%
Construction	5	1.16%
Education	77	17.87%
Finance and Insurance	21	4.87%
Health Care and Social Assistance	18	4.18%
Hospitality and Tourism	3	0.70%
High-Tech (IT, Telecommunications, Biotech, etc.)	109	25.29%
Professional, Scientific, and Technical Services	31	7.19%
Manufacturing	30	6.96%
Media	4	0.93%
Nonprofit	10	2.32%

Mining, Oil, and Gas	4	0.93%
Public Sector	8	1.86%
Retail and Consumer Goods	12	2.78%
Real Estate, Rental, and Leasing	4	0.93%
Transportation and Logistics	4	0.93%
Utilities/Energy	22	5.10%
Defense & Aerospace	5	1.16%
Other	11	2.55%
Total	431	100.00%

Q3. Total annual revenue with goods and services (Please answer for the year 2021 and in U.S. dollars).	**Count**	**Percentage**
Less than $1 billion	226	56.50%
$1 billion to less than $10 billion	59	14.75%
Over $10 billion	115	28.75%
Total	400	100.00%

Q4. Number of employees in your organization (Please answer for the year 2021).	**Count**	**Percentage**
Less than 1,000	212	49.53%
1,000 to 9,999	79	18.46%
10,000 to 99,999	87	20.33%
100,000 to 999,999	50	11.68%
Total	428	100.00%

Q5. Expenditure for research, development, and innovation (Please answer for the year 2021 and in U.S. dollars).	**Count**	**Percentage**
Less than $1 million	144	40.45%
$1 million to less than $10 million	77	21.63%
$10 million to less than $100 million	57	16.01%
$100 million to less than $1 million	43	12.08%
$1 billion or more	35	9.83%
Total	356	100.00%

Q6. The percentage of revenue in the year 2021 from products or services new to your organization in the past three years.	Count	Percentage
Less than 5%	68	22.44%
5% to less than 10%	48	15.84%
10% to less than 20%	41	13.53%
20% to less than 40%	76	25.08%
40% or more	70	23.10%
Total	303	100.00%

Q7. The number of employees devoted to the development of software in your organization.	Count	Percentage
Less than 10	168	38.98%
10 to 99	90	20.88%
100 to 999	81	18.79%
1,000 to 9,999	54	12.53%
10,000 or more	38	8.82%
Total	431	100.00%

Q8. The year that your company was founded.	Count	Percentage
1665	1	0.23%
1668	1	0.23%
1753	1	0.23%
1783	1	0.23%
1789	2	0.46%
1836	1	0.23%
1837	1	0.23%
1845	1	0.23%
1847	1	0.23%
1860	1	0.23%
1865	3	0.70%
1866	1	0.23%
1868	3	0.70%
1869	1	0.23%

Q8. The year that your company was founded.	Count	Percentage
1870	2	0.46%
1871	2	0.46%
1873	1	0.23%
1874	1	0.23%
1876	4	0.93%
1880	1	0.23%
1882	2	0.46%
1885	2	0.46%
1886	3	0.70%
1891	1	0.23%
1895	2	0.46%
1897	2	0.46%
1898	3	0.70%
1899	1	0.23%

Q8. The year that your company was founded.	Count	Percentage
1900	2	0.46%
1902	1	0.23%
1903	1	0.23%
1904	1	0.23%
1905	1	0.23%
1906	1	0.23%
1908	1	0.23%
1909	1	0.23%
1910	2	0.46%
1911	7	1.62%
1912	2	0.46%
1916	1	0.23%
1917	2	0.46%
1919	1	0.23%
1920	1	0.23%
1921	2	0.46%
1922	3	0.70%
1923	1	0.23%
1924	2	0.46%
1926	2	0.46%
1927	1	0.23%
1928	2	0.46%
1930	1	0.23%
1932	1	0.23%
1933	1	0.23%
1934	1	0.23%
1935	2	0.46%
1936	1	0.23%
1938	1	0.23%
1939	2	0.46%
1944	1	0.23%
1945	2	0.46%

Q8. The year that your company was founded.	Count	Percentage
1946	2	0.46%
1947	1	0.23%
1948	5	1.16%
1949	1	0.23%
1950	3	0.70%
1951	2	0.46%
1955	1	0.23%
1956	1	0.23%
1957	1	0.23%
1958	4	0.93%
1960	4	0.93%
1961	1	0.23%
1962	6	1.39%
1965	2	0.46%
1966	1	0.23%
1967	3	0.70%
1968	4	0.93%
1969	6	1.39%
1970	2	0.46%
1971	1	0.23%
1972	5	1.16%
1973	2	0.46%
1974	3	0.70%
1975	1	0.23%
1976	5	1.16%
1977	4	0.93%
1978	2	0.46%
1980	5	1.16%
1981	1	0.23%
1982	7	1.62%
1983	5	1.16%
1984	5	1.16%

Q8. The year that your company was founded.	Count	Percentage
1985	2	0.46%
1986	3	0.70%
1987	3	0.70%
1988	2	0.46%
1989	3	0.70%
1990	3	0.70%
1991	4	0.93%
1992	2	0.46%
1993	4	0.93%
1994	4	0.93%
1996	2	0.46%
1997	1	0.23%
1998	8	1.86%
1999	10	2.32%
2000	9	2.09%
2001	3	0.70%
2002	2	0.46%
2003	4	0.93%
2004	5	1.16%

Q8. The year that your company was founded.	Count	Percentage
2005	2	0.46%
2006	8	1.86%
2007	8	1.86%
2008	8	1.86%
2009	6	1.39%
2010	8	1.86%
2011	5	1.16%
2012	13	3.02%
2013	8	1.86%
2014	5	1.16%
2015	11	2.55%
2016	12	2.78%
2017	13	3.02%
2018	13	3.02%
2019	14	3.25%
2020	15	3.48%
2021	12	2.78%
2022	3	0.70%
Total	431	100.00%

Q9: Are you answering the following questions from the perspective of an organizational subunit or project within your organization?	Count	Percentage
Yes	142	32.87%
No	289	67.13%
Total	431	100.00%

Q10. Please provide a brief description of your subunit or project below.	
ID	Responses
1	The management consulting division of the capgemini group
2	The org-unit ensures the consistency of the application and infrastructural architecture, defining standards and managing enterprise architecture models. In addition, the org-unit ensures the implementation of the technological innovation roadmap, do research on disruptive technology and collaborates on business innovation.
3	Cloud Division
4	Client's project
5	I work in healthcare
6	New business development and technology sourcing at R&D subsidiaries
7	Digital Design: Electronic Development (HW, SW, H&H), IoT, Ux, Cloud, APP
8	The Innovation Unit provides mentorship to the whole organization (Credem Group) and promotes innovation activities in order to change how people approach problems in their day by day activities
9	Construction of shafts
10	Company specialised in offering management services and optimisation of financial resources for research, development and innovation activities in companies and organisations. We offer global solutions for the financing and management of the innovation process in companies with the aim of optimising their resources and boosting their growth to make them more competitive in the market.
11	Product & technology development for the cyber and Security Solutions Unit
12	Innovation & Intellectual Property
13	Intellectual Property
14	Innovation
15	Strategic Management Department
16	Develops firmware and applications software for an ultra wideband transceiver
17	I overview all the company

Q10. Please provide a brief description of your subunit or project below.	
18	The main goal of my organizazitional unit is to provide IT support to Business Users IT and manage IT projects involved
19	Service Operations Department. Our goal is to manage the continuity and the software development of our business services
20	A Business School
21	Our subunit studies food design under a bigger umbrella lab that studies design in general.
22	Developing digital tools in the plants to validate the noise from the products
23	I am in charge of five out of the eighteen business units that my company has.
24	GTM Strategy for Manufacturing Industry
25	I work for a subunit in the Innovation and Human Resource Department
26	Center for Corporate Innovation
27	blb
28	Corporate Innovation
29	Product manager at a fintech firm
30	The subunit is it the IT department for a particular college. This unit is responsible for assisting Faculty and Staff with technological needs.
31	Developing new cruise projects
32	IT Business Operations - includes IT Program Management, IT Financial Management, IT Administration, Vendor Management, Enterprise Architecture, Innovation
33	Open Innovation City; state-funded project; Fostering open innovation culture and exploring open innovation methods across the entire urban ecosystem
34	Business development, open innovation, M&A
35	Seperate investment fund of 250mln Euro's under asset
36	e2e development, delivery and maintenance of SW Applications for managing telecommunications networks
37	We are an institute within a larger university with responsibility for leadership development and professional/executive education.
38	R&D/Innovation

	Q10. Please provide a brief description of your subunit or project below.
39	Open innovation process to connect a big company with startups. we use a platform to boost the process.
40	Project provides answers for user's questions.
41	Business college
42	As a startup, we have one main product. It's generating revenue but the company is not profitable yet. Our software is for supply planners in pharmaceutical companies. We help manufacturers forecast how much to produce to avoid stock-outs and expiry.
43	Development of Crowdsourcing platform
44	Remaining questions are answered for the CTO organization of a global company of about 70.000 employees. The CTO Organization and its units represent about 1500 employees.
45	Entrepreneurship Education
46	Business development, public/private partnerships
47	Semiconductor Design And Manufacturing For Digital World.
48	Strategy Customer Experience and data driven transformation
49	Country unit
50	I am part of the Infrastructure Global Practice and focus on the ECA region.
51	R&D Packaging
52	Business school
53	M&A Advisory, focused on the tech sector
54	Strategy Research Unit of University
55	Department
56	Easier to use and modify if necessary
57	New business Development
58	My subunit is responsible for providing proptech solutions to real estate sector, that is technology data & information management, we also have an spark fund to invest & acquire proptech startups.
59	Global marketing
60	magicbricks.com
61	Maitain the latest gaming network and company's internal system by using ERP
62	Education platform

	Q10. Please provide a brief description of your subunit or project below.
63	Program office
64	Research focused on business decision making, critical societal needs and application of knowledge.
65	IT department responsible for developing and managing global enterprise applications.
66	Management Department at a College of Business
67	Finance Data Strategy & Analytics team — IT embedded in a financial function, mostly finance folks with a streak of data geekery
68	hardware development
69	Na
70	Telco oriented vertical for delivering application orchestration infrastructure
71	AWS, part of Amazon
72	Product research and development
73	Physical POS terminal launch for taxi drivers in Turkey
74	Education environment, fixed wireless infrastructure for remote learning
75	Part of Radio Access Network broadly.
76	Academic department
77	We are a Corporate Venture Team in charge to explore new digital business models through a venture building innovation process (Ideation & research, Prototyping and validation, MVP, scaling)
78	enabling our clients to unlock the digital future with our ecosystem. So, whatever you need to transform your business, making an impact to society, create unseen opportunities – we have the right people, the knowledge and partners to achieve your vision.
79	Global Technology
80	Building glass
81	Global operations
82	IBM Consulting (formerly called Global Business Services)
83	Group risk Services, insurance, business continuity
84	Recruitment services to the life science sector
85	Business development

	Q10. Please provide a brief description of your subunit or project below.
86	Innovative Solutions in Health Care like Self-driving Hospital beds, drones for drug delivery using climat infrastructure
87	Solution Design Unit and Business Analysis Department - we work with Proposals and Delivery to propose best solution response to our clients problems
88	Exploring the next big thing for the organization thru the development of new ways of monetization for our digital assets
89	I am head of Fraunhofer ISST. The institute is one of 76 institutes in total within the Fraunhofer Gesellschaft.
90	Value exchange System
91	n/a
92	Building software platform for Trust engineering needs for our company's Software products offered as SaaS
93	We build products and services for the future state of banking using emerging tech
94	No license fees, no revenue share
95	Na
96	I lead multicloud devOps to enable the firm's LOBs to develop and operate securely and with resilience in public clouds
97	Rutgers Business School
98	We build software but use open source technology to help build some of the key pieces that drive platform development. Coupled with proprietary AI/machine learning we deliver data output sometimes experimentally with open sources software
99	Responsible Innovation & Entrepreneurship Research Initiatives: The main goal of this initiative is to support high-impact and rigorous faculty scholarship in the realm of Responsible Innovation and Entrepreneurship (RI&E) such that it supports innovation and ethics-oriented elements of the university's mission.
100	Corporate Innovation
101	Berkeley has several departments that write and create software
102	Honeywell Energy
103	Education and research in international business, government, and economics

	Q10. Please provide a brief description of your subunit or project below.
104	Now saudíes, strategy + documentación. In the near past open innovación área.
105	I work on Education projects at Adobe
106	open source AI and Data
107	Benchmarking - Development of a research database
108	We are a marketing research company. I work on a client services team that conducts qualitative research and provides analysis and reporting on that research.
109	Creating a platform through both an IT capability and organizational collaborations to create market access opportunities
110	I work in the corporate Venturing and innovation division. We help corporations in their innovation processes through interaction with different stakeholders, mostly startups. We also support the development of the Italian innovation ecosystem building bridges between stakeholder with different goals, such as: investors, corporates, research institutions, academia, startups and professionals
111	Department for Strategy and Management (Part of University)
112	I am leading 42 Berlin and 42 Wolfsburg which are higher education ventures in the 42 Network (approx 40 schools internationally)
113	Aims to provide scientific skills and knowledge related to research activity, enabling the award of the PhD degree
114	Research and development department
115	The R &D department of a multi-energy company
116	We are providing different kinds of IT Compliance related services to clients. This includes IT-Audits on the technological and organizational layer, IT transformation compliance as well as implementation projects.
117	It deals with Management courses
118	Innovation Sourcing for Sustainability
119	Research group at a university.
120	Commercial distribution channel for multiple divisions.
121	eSTiP- www.estip-hcl.com- Open Innovation active at HCL since 8 years where we've grown the ecosystem 10x- 1500+ partners and a self sustainable organization providing innovation for internal and client asks.

	Q10. Please provide a brief description of your subunit or project below.
122	Open source standards and emerging technology applications demonstrating those standards.
123	Center within larger org
124	use open source softwares to digest financial market information and turn into investment insights
125	Research and development
126	higher education
127	Research, developing next Gen technologies
128	Creating a big data infrastructure for our production data
129	Lead technology strategies such as software technology and so on.
130	New energy develop, invest, build and opetation
131	- Used in extensibility - Used in platform after formal legal and business review: security, streaming services, industries
132	proprietary client clinical file and record management system

	Q10. Please provide a brief description of your subunit or project below.
133	core engineering, software and services
134	C
135	Open Source Program Office
136	Every process is based on open source software
137	Standard and extensible implementation that will be maintained up to date. Low cost.
138	Working on capabilities development of R&D intensive firms of Lithuania
139	Providing solutions by leveraging OSS
140	Open source software research organization
141	Research department publishes qualitative and quantitative studies on open source, some of which are sponsored by 3rd parties.
142	Garwood Center

Section C: Involvement in Open Source Communities

Q11: Is your organization using or contributing to open source software (OSS)? OSS is defined as software designs that are distributed under a license, which complies with the Open Source Definition or the Free Software Foundation's Four Freedoms.	Count	Percentage
Yes	272	63.11%
No	159	36.89%
Total	431	100.00%

Q12: In what year did your organization begin to work with OSS?	Count	Percentage
1980	1	0.78%
1990	5	3.91%
1993	2	1.56%
1995	3	2.34%
1998	1	0.78%
1999	2	1.56%
2000	10	7.81%
2002	1	0.78%
2003	2	1.56%
2004	3	2.34%
2006	2	1.56%
2007	3	2.34%
2008	7	5.47%
2009	1	0.78%
2010	4	3.13%
2011	3	2.34%
2012	5	3.91%
2013	6	4.69%
2014	2	1.56%
2015	5	3.91%
2016	12	9.38%
2017	11	8.59%
2018	8	6.25%
2019	11	8.59%
2020	9	7.03%
2021	8	6.25%
2022	1	0.78%
Total	128	100.0%

Q13: How often does your organization participate in each of the following aspects of the development of OSS?	Never		Seldom		Sometimes		Most times		Always		Total
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
We are a paying member or sponsor of an OSS foundation.	91	39.06%	42	18.03%	63	27.04%	8	3.43%	29	12.45%	233
We buy support services and subscriptions for enterprise editions of OSS.	38	16.31%	46	19.74%	94	40.34%	28	12.02%	27	11.59%	233
We provide upstream contributions from our organization back to the OSS community.	47	20.17%	45	19.31%	79	33.91%	26	11.16%	36	15.45%	233
We are the financial sponsor of public events that foster OSS (e.g., conferences).	100	42.92%	52	22.32%	49	21.03%	14	6.01%	18	7.73%	233
We have internal policies that foster the use of OSS (e.g., consumption policies).	37	15.88%	36	15.45%	72	30.90%	39	16.74%	49	21.03%	233

Q13: How often does your organization participate in each of the following aspects of the development of OSS?	MIN	MAX	MEAN		Std. Deviation
BASIC STATISTICS (5-point Likert scale: 1 = Never ... 5 = Always)	Statistic	Statistic	Statistic	Std. Error	Statistic
We are a paying member or sponsor of an OSS foundation.	1	5	2.322	0.088	1.350
We buy support services and subscriptions for enterprise editions of OSS.	1	5	2.828	0.078	1.187
We provide upstream contributions from our organization back to the OSS community.	1	5	2.824	0.086	1.306
We are the financial sponsor of public events that foster OSS (e.g., conferences).	1	5	2.133	0.082	1.251
We have internal policies that foster the use of OSS (e.g., consumption policies).	1	5	3.116	0.088	1.339

Q14: Has your organization instituted an Open Source Program Office (OSPO)? The OSPO is a typical organizational unit responsible for creating directives, policies, and guidelines for OSS community engagement, often composed of software developers, software architects, lawyers, and product managers.	Count	Percentage
Yes	45	19.31%
No	188	80.69%
Total	233	100.00%

Q15: How often does your organization use an OSPO to manage open source in each of the following aspects?	Never		Seldom		Sometimes		Most times		Always		Total
	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
We use an OSPO to facilitate the use of open source, license compliance reviews, and oversight.	2	4.44%	3	6.67%	12	26.67%	13	28.89%	15	33.33%	45
We use an OSPO to ensure high-quality and frequent releases to open source communities.	1	2.22%	3	6.67%	17	37.78%	13	28.89%	11	24.44%	45
We use an OSPO to engage with developer communities and participate in events.	1	2.22%	0	0.00%	16	35.56%	13	28.89%	15	33.33%	45
We use an OSPO to foster an open source culture.	1	2.22%	1	2.22%	16	35.56%	14	31.11%	13	28.89%	45
We use an OSPO to train employees.	1	2.22%	6	13.33%	13	28.89%	13	28.89%	12	26.67%	45
We use an OSPO to track OSS usage.	3	6.67%	3	6.67%	13	28.89%	13	28.89%	13	28.89%	45

Q15: How often does your organization use an OSPO to manage open source in each of the following aspects?	MIN	MAX	MEAN		Std. Deviation
BASIC STATISTICS (5-point Likert scale: 1 = Never ... 5 = Always)	Statistic	Statistic	Statistic	Std. Error	Statistic
We use an OSPO to facilitate the use of open source, license compliance reviews, and oversight.	1	5	3.773	0.169	1.118
We use an OSPO to ensure high-quality and frequent releases to open source communities.	1	5	3.636	0.149	0.990
We use an OSPO to engage with developer communities and participate in events.	1	5	3.886	0.143	0.945
We use an OSPO to foster an open source culture.	1	5	3.795	0.144	0.954
We use an OSPO to train employees.	1	5	3.614	0.163	1.083
We use an OSPO to track OSS usage.	1	5	3.636	0.175	1.163

Q16: Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:	No benefits		Low benefits		Medium benefits		High benefits		Very high benefits		Total
BASIC STATISTICS (5-point Likert scale: 1 = No benefits ... 5 = Very high benefits)	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
Attractive IT work environment / motivation for employees.	15	7.18%	24	11.48%	67	32.06%	81	38.76%	22	10.53%	209
Active community for knowledge exchange.	8	3.83%	20	9.57%	58	27.75%	82	39.23%	41	19.62%	209
Faster development speed.	5	2.39%	13	6.22%	54	25.84%	87	41.63%	50	23.92%	209
High security of software.	12	5.77%	51	24.52%	76	36.54%	51	24.52%	18	8.65%	209
High stability, low error susceptibility in OSS code.	9	4.33%	46	22.12%	79	37.98%	56	26.92%	18	8.65%	209
Cost savings (i.e., lower total cost of ownership) (higher productivity).	6	2.87%	16	7.66%	48	22.97%	80	38.28%	59	28.23%	209

Additional revenue opportunities / access to new markets.	35	16.75%	50	23.92%	68	32.54%	37	17.70%	19	9.09%	209
Independence from proprietary providers.	10	4.78%	20	9.57%	65	31.10%	69	33.01%	45	21.53%	209
Open standards & interoperability.	7	3.35%	20	9.57%	50	23.92%	72	34.45%	60	28.71%	209
Strong support from OSS providers.	20	9.57%	51	24.40%	83	39.71%	34	16.27%	21	10.05%	209

Q16: Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:	**MIN**	**MAX**	**MEAN**		**Std. Deviation**
BASIC STATISTICS (5-point Likert scale: 1 = No benefits ... 5 = Very high benefits)	Statistic	Statistic	Statistic	Std. Error	Statistic
Attractive IT work environment / motivation for employees.	1	5	3.333	0.072	1.033
Active community for knowledge exchange.	1	5	3.599	0.071	1.023
Faster development speed.	1	5	3.778	0.067	0.960
High security of software.	1	5	3.053	0.071	1.025
High stability, low error susceptibility in OSS code.	1	5	3.130	0.069	0.999
Cost savings (i.e., lower total cost of ownership) (higher productivity).	1	5	3.807	0.071	1.025
Additional revenue opportunities / access to new markets.	1	5	2.792	0.082	1.174
Independence from proprietary providers.	1	5	3.565	0.075	1.077
Open standards & interoperability.	1	5	3.744	0.075	1.078
Strong support from OSS providers.	1	5	2.918	0.076	1.087

Q16: Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:	
Other benefits (please specify) (5-point Likert scale: 1 = No benefits ... 5 = Very high benefits)	**Rate**
Client-specific requests will result in benefits for the company	2
Some SW only available in OSS	3
Trust from people seeing familiar UI	3
Access to data science from University Knowledge and Network	3
Software "parts" accelerate some R&D	3
Adds additional features and capabilities	4

Q16: Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:	
Other benefits (please specify) (5-point Likert scale: 1 = No benefits ... 5 = Very high benefits)	**Rate**
Having clear guidelines of OSS across communities	4
Setting standards for the industry	4
Ability to focus on proprietary functionality outside of OS domain	4
Provides some attractiveness for job seekers	4
Networking	4

Q16: Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:	
Other benefits (please specify) (5-point Likert scale: 1 = No benefits … 5 = Very high benefits)	**Rate**
We develop and open a software. This helps us increasing the market of your company.	4
ACCESS TO TENDER FOR THE PUBLIC ADMINISTRATION	5
Access to open innovation	5
Ability to use developed with others' OSS software (integrating multiple competences), but adjust it to our needs and populate it with specific for our company and its stakeholders' needs within the license.	5
Access to top talent	5
Plenty. List would be too long.	5
OSS is a trust anchor in itself; plus, it allows to utilize the power of the many in fields where no single actor alone has sufficient resources (e.g., in the field of data infrastructures).	5
Foster education and research	5
Complete control of the software, which has very large benefits for analytics, support, and maintenance. Also: increased flexibility; ability to adapt and modify for changing technological and market conditions. For startups, these benefits are quite substantial. They allow us to prototype our needs with OSS, and if a proprietary product does not fit our needs, we stay with it (almost always). Development is often much faster with OSS, with fewer lines of code needing to be written.	5

Q16: Based on your experience, rate the degree of benefits derived from using or contributing to OSS for your organization for each of the following:	
Other benefits (please specify) (5-point Likert scale: 1 = No benefits … 5 = Very high benefits)	**Rate**
Customers ask for solutions based on OSS	5
Speed to market	5
Thought leadership and faster convergence on tools and methods.	5
Experimentation	5
Community creation	5
Freedom of personalization based on unique business needs	5
Freedom of action and access to volunteer talent	5
Long-term costs from providers (e.g., salesforce)	
Very recently sought after by our company due to changing external expertise we need access to.	

Q17: Based on your experience, rate the primary costs associated with the use of or contribution to OSS for your organization for each of the following:	No Costs		Low Costs		Medium Costs		High Costs		Very High Costs		Total
Lost revenues (customers using product for free, competitors free riding).	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	Count	Percentage	
Reduced ability to differentiate vs. competitors, since they can use same software as well.	63	30.14%	87	41.63%	47	22.49%	9	4.31%	3	1.44%	209

Costs related to legal uncertainty, such as developer and supply chain product liability.	55	26.32%	86	41.15%	57	27.27%	11	5.26%	0	0.00%	209
Hidden support costs due to lack of commercial support and missing enterprise versions.	42	20.19%	70	33.65%	61	29.33%	26	12.50%	9	4.33%	209
Switching cost from proprietary to OSS.	25	12.02%	61	29.33%	75	36.06%	38	18.27%	9	4.33%	209
Cost due to security gaps.	44	21.15%	67	32.21%	62	29.81%	25	12.02%	10	4.81%	209
Cost to reduce legal uncertainties regarding licensing.	31	15.05%	55	26.21%	72	34.47%	37	17.48%	14	6.80%	209
Cost for training.	48	22.97%	64	30.62%	58	27.75%	34	16.27%	5	2.39%	209
Cost of selection due to abundant choice of OSS.	31	14.83%	77	36.84%	74	35.41%	21	10.05%	6	2.87%	209
Test cost due to missing certifications for OSS.	39	18.66%	85	40.67%	70	33.49%	15	7.18%	0	0.00%	209

Q17: Based on your experience, rate the primary costs associated with the use of or contribution to OSS for your organization for each of the following:	**MIN**	**MAX**	**MEAN**		**Std. Deviation**
BASIC STATISTICS (5-point Likert scale: 1 = No Costs ... 5 = Very high Costs)	Statistic	Statistic	Statistic	Std. Error	Statistic
Lost revenues (customers using product for free, competitors free riding).	1	5	2.063	0.064	0.920
Reduced ability to differentiate vs. competitors, since they can use same software as well.	1	4	2.121	0.060	0.859
Costs related to legal uncertainty, such as developer and supply chain product liability.	1	5	2.473	0.075	1.078
Hidden support costs due to lack of commercial support and missing enterprise versions.	1	5	2.739	0.072	1.033
Switching cost from proprietary to OSS.	1	5	2.469	0.076	1.096
Cost due to security gaps.	1	5	2.729	0.078	1.117
Cost to reduce legal uncertainties regarding licensing.	1	5	2.464	0.076	1.092
Cost for training.	1	5	2.473	0.066	0.949
Cost of selection due to abundant choice of OSS.	1	4	2.295	0.060	0.856
Test cost due to missing certifications for OSS.	1	5	2.396	0.071	1.023

Q17: Based on your experience, rate the primary costs associated with the use of or contribution to OSS for your organization for each of the following:	
Other costs (please specify) (5-point Likert scale: 1 = No costs ... 5 = Very high costs)	**Rate**
Freedom of action and access to talent	1
Pro services consumption	2
Coordination costs... time in committees and managing human complexities.	2
Packaging / software distribution / maintenance hurdle	2
Downtime from interoperability bugs and rollback	3
Incomplete feature sets / increased time to bug resolution vs. homegrown solutions	3
Development costs may be higher than anticipated, since OSS products often have limited scope or bounds that do not fit our needs. Also, managing the dependencies of OSS is often a challenge, but manageable with skilled developers.	3
Cost of changing internal procurement system rules	4
Users support the OSS idea, but—at least implicitly—demand a "managed service" (release management, complexity management, etc.)	4
Development and modification time	4
Community building costs	4
Ban use of OSS by clients	5

Q18: What is your assessment of the overall benefit–cost ratio of using or contributing to OSS?	Count	Percentage
(1 = Costs greatly exceed the benefits... 7 = Benefits greatly exceed the costs)		
Costs greatly exceed the benefits	6	2.90%
Costs exceed the benefits	29	14.01%
Costs slightly exceed the benefits	9	4.35%
Costs are roughly equal to the benefits	22	10.63%
Benefits slightly exceed the costs	30	14.49%
Benefits exceed the costs	64	30.92%
Benefits greatly exceed the costs	47	22.71%
Total	207	100.00%
Mean (Std. Error)		**5.034 (.125)**
Std. Deviation		**1.799**

Q19: How is the overall benefit–cost ratio of using or contributing to OSS trending in your organization over the past five years? (1 = Costs are rising much faster than benefits... 7 = Benefits are rising much faster than costs)	Count	Percentage
Costs are rising much faster than benefits	3	1.45%
Costs are rising faster than benefits	10	4.83%
Costs are rising somewhat faster than benefits	21	10.14%
The cost–benefit ratio has been stable	72	34.78%
Benefits are rising somewhat faster than costs	43	20.77%
Benefits are rising faster than costs	43	20.77%
Benefits are rising much faster than costs	15	7.25%
Total	207	100.00%
Mean (Std. Error)		**4.599 (.092)**
Std. Deviation		**1.329**

Q20: Using any number from 0 to 10, where 0 is no costs and 10 is extremely high costs, what number would you use to rate the costs of using and/or contributing to OSS?	Count	Percentage
0	4	1.93%
1	10	4.83%
2	31	14.98%
3	47	22.71%
4	27	13.04%
5	37	17.87%
6	33	15.94%
7	14	6.76%
8	2	0.97%
9	0	0.00%
10	2	0.97%
Total	207	100.00%
Mean (Std. Error)		**5.048 (.130)**
Std. Deviation		**1.874**

Q21: Using any number from 0 to 10, where 0 is no benefits and 10 is extremely high benefits, what number would you use to rate the benefits of using and/or contributing to OSS?	Count	Percentage
0	4	0.00%
1	10	0.48%
2	31	1.45%
3	47	1.93%
4	27	5.80%
5	37	13.04%
6	33	12.56%
7	14	20.29%
8	2	19.81%
9	0	16.43%
10	2	8.21%
Total	207	100.00%
Mean (Std. Error)		**5.034 (.132)**
Std. Deviation		**1.904**

Q21/Q20: the overall benefit–cost ratio of using or contributing to OSS (by number)	Count	Percentage	Cumulative Percent
0.5	1	0.48%	0.48%
0.55	1	0.48%	0.97%
0.75	1	0.48%	1.45%
0.82	1	0.48%	1.93%
0.83	2	0.97%	2.90%
0.86	3	1.45%	4.35%
0.88	3	1.45%	5.80%
1	33	15.94%	21.74%
1.11	1	0.48%	22.22%
1.13	3	1.45%	23.67%
1.14	5	2.42%	26.09%
1.17	4	1.93%	28.02%
1.2	5	2.42%	30.43%

1.25	6	2.90%	33.33%
1.29	7	3.38%	36.71%
1.33	12	5.80%	42.51%
1.38	1	0.48%	43.00%
1.4	2	0.97%	43.96%
1.43	8	3.86%	47.83%
1.5	5	2.42%	50.24%
1.57	1	0.48%	50.72%
1.6	4	1.93%	52.66%
1.67	6	2.90%	55.56%
1.75	7	3.38%	58.94%
1.8	9	4.35%	63.29%
1.83	3	1.45%	64.73%
2	18	8.70%	73.43%
2.2	1	0.48%	73.91%
2.25	10	4.83%	78.74%
2.33	1	0.48%	79.23%
2.5	3	1.45%	80.68%
2.67	4	1.93%	82.61%
2.75	4	1.93%	84.54%
3	10	4.83%	89.37%
3.33	8	3.86%	93.24%
3.67	3	1.45%	94.69%
5	5	2.42%	97.10%
5.5	3	1.45%	98.55%
8	1	0.48%	99.03%
10	1	0.48%	99.52%
11	1	0.48%	100.00%
Total	207.00	100.00%	□
Mean (Std. Error)		**1.936 (.095)**	
Std. Deviation		**1.367**	

Q22: Approximately how many lines of software code were included in this new offering? (1 = Less than 1,000 lines of code ... 8 = 160,000 lines of code or more)	Count	Percentage	Cumulative Percent
Less than 1,000 lines of code	13	14.94%	14.94%
1,000 to less than 5,000 lines of code	14	16.09%	31.03%
5,000 to less than 10,000 lines of code	13	14.94%	45.98%
10,000 to less than 20,000 lines of code	13	14.94%	60.92%
20,000 to less than 40,000 lines of code	6	6.90%	67.82%
40,000 to less than 80,000 lines of code	5	5.75%	73.56%
80,000 to less than 160,000 lines of code	7	8.05%	81.61%
160,000 lines of code or more	16	18.39%	100.00%
Total	87	100.00%	□
Mean (Std. Error)		**4.241(0.265)**	
Std. Deviation		**2.473**	

Q23: Approximately what percentage of those lines of code were created from OSS? (1 = 0 to less than 20% ... 5 = More than 80%)	Count	Percentage	Cumulative Percent
0 to less than 20%	24	24.00%	24.00%
20% to less than 40%	26	26.00%	50.00%
40% to less than 60%	18	18.00%	68.00%
60% to less than 80%	10	10.00%	78.00%
More than 80%	22	22.00%	100.00%
Total	100	100.0%	□
Mean (Std. Error)		**2.800(0.148)**	
Std. Deviation		**1.477**	

Q24: What was your approximate cost of creating these lines of code from OSS in the project, including a) bug fixing, b) licensing obligations, c) legal checks, d) compliance management? (Please answer in U.S. Dollars.) (1 = Less than $100,000 ... 5 = $5 million or more)	Count	Percentage	Cumulative Percent
Less than $100,000	55	56.70%	56.70%
$100,000 to less than $500,000	18	18.56%	75.26%
$500,000 to less than $1 million	11	11.34%	86.60%
$1 million to less than $5 million	10	10.31%	96.91%
$5 million or more	3	3.09%	100.00%
Total	97	100.0%	□
Mean (Std. Error)		**1.845(0.118)**	
Std. Deviation		**1.167**	

Q25: For those OSS lines of code: How much would it have cost you to write the necessary lines of code to achieve that functionality with your own software, rather than with OSS software, including ongoing support and maintenance of the code? (1 = Less than ½ of the OSS cost in Q24 ... 5 = 2 times or more the OSS cost in Q24)	Count	Percentage	Cumulative Percent
Less than ½ of the OSS cost in Q24	13	14.61%	14.61%
½ to less than 1 times the OSS cost in Q24	6	6.74%	21.35%
About the same cost as OSS cost in Q24	10	11.24%	32.58%
more than 1 to less than 2 times the OSS cost in Q24	19	21.35%	53.93%
2 times or more the OSS cost in Q24	41	46.07%	100.00%
Total	89	100.0%	□
Mean (Std. Error)		**3.775(0.155)**	
Std. Deviation		**1.460**	

Q26: If you had not been able to use OSS in this project: What was your next-best alternative to achieve a similar level of functionality in your release?	Count	Percentage
Commercial / proprietary solutions	61	50.41%
In-house development	44	36.36%
No alternatives	10	8.26%
SaaS Solution	3	2.48%
Blockchain	2	1.65%
Exit business	1	0.83%
Total	121	100.0%

Q27: Approximately what would this next-best alternative have cost you to obtain, including ongoing support and maintenance of the code? (1 = Less than ½ of the OSS cost in Q24 ... 6 = 4 times or more the OSS cost in Q24)	Count	Percentage	Cumulative Percent
Less than ½ of the OSS cost in Q24	9	9.00%	9.00%
½ to less than 1 times the OSS cost in Q24	5	5.00%	14.00%
About the same cost as OSS cost in Q24	11	11.00%	25.00%
More than 1 to less than 2 times the OSS cost in Q24	25	25.00%	50.00%
2 to less than 4 times the OSS cost in Q24	21	21.00%	71.00%
4 times or more the OSS cost in Q24	29	29.00%	100.00%
Total	100	100.0%	□
Mean (Std. Error)		**4.310(0.156)**	
Std. Deviation		**1.555**	

Q28: If you had to purchase this level of software functionality in the market (from another software company, developer, or consultant): What would you likely have paid to obtain that functionality, including ongoing support and maintenance of this code from the market? (1 = Less than ½ of the OSS cost in Q24 ... 6 = 4 times or more the OSS cost in Q24)	Count	Percentage	Cumulative Percent
Less than ½ of the OSS cost in Q24	6	6.12%	6.12%
½ to less than 1 times the OSS cost in Q24	7	7.14%	13.27%
About the same cost as OSS cost in Q24	10	10.20%	23.47%
More than 1 to less than 2 times the OSS cost in Q24	21	21.43%	44.90%
2 to less than 4 times the OSS cost in Q24	24	24.49%	69.39%
4 times or more the OSS cost in Q24	30	30.61%	100.00%
Total	98	100.0%	□
Mean (Std. Error)		**4.429(0.151)**	
Std. Deviation		**1.500**	

Acknowledgements

Support for this survey from the Linux Foundation is gratefully acknowledged. Visiting Scholar Qi Cao of Jilin University provided excellent research support. Adriana Macias, Tristan Gaspi, and Mehdi Montakhabi assisted in the development of the survey sample. Useful comments and suggestions were received from Hilary Carter, Irving Wladawsky-Berger, Maria Roche, Mike Dolan, Stephen Walli, Stephen Hendrick, and the Linux Foundation Research Advisory Board. Thanks also to Knut Blind and Sachiko Muto for sharing the results of the earlier survey on OSS adoption in the E.U. All remaining errors are mine alone.

About the author

Henry Chesbrough is best known as "the father of open innovation". He teaches at the Haas School of Business at the University of California-Berkeley, where he is the faculty director of the Garwood Center for Corporate Innovation. He is also Maire Tecnimont Professor of Open Innovation and Sustainability at Luiss University in Rome. Previously he was an assistant professor at Harvard Business School. He holds a PhD from UC Berkeley, an MBA from Stanford, and a BA from Yale University.

He has written books such as *Open Innovation* (Harvard Business School Press, 2003), *Open Business Models* (Harvard Business School Press, 2006), *Open Services Innovation* (Jossey-Bass, 2011), and *Open Innovation Results* (Oxford, 2020). His research has been cited more than 100,000 times, according to Google Scholar.

He has been recognized as one of the leading business thinkers by Thinkers50 several times. He received an Innovation Luminary award from the European Commission in 2014. He received the Industrial Research Institute Medal of Achievement in 2017, the Viipuri Prize from Lappeenranta University of Technology in 2022, the Herbert Simon Award of the Rajk College for Advanced Studies in 2022, and holds two honorary doctorates.

Endnotes

1 This section draws from the recent case study of the Linux Foundation, "Leading Through Influence at Scale: Open Source Security at the Linux Foundation," Product #: B6019-PDF-ENG, by Henry Chesbrough.

2 https://opencommons.uconn.edu/cgi/viewcontent.cgi?article=1009&context=libr_pubs

3 Other open source umbrella foundations include the Apache Software Foundation, the Mozilla Foundation, and the Eclipse Foundation, and their models of governing open source are similar. Some of the most commonly used open source licenses include various versions of the GNU General Public License, the Mozilla Public License, and the Apache License.

4 For an analysis of the strategic value of OSS in a firm's innovation strategy, see West and Gallagher (2006) and Zemlin (2022).

5 Considerable academic research has explained how and why these volunteers create such software. For reviews of such research, see von Krogh and von Hippel (2006) and von Krogh et al. (2012).

6 See Hilary Carter (2023) for an extended discussion of this approach to valuing OSS. Irving Wladawsky-Berger has observed that measuring the often intangible benefits of using OSS are similar to the challenges in measuring the value of services more generally. See his recent blog entry, "The Current State of Service Science."

7 We appreciate Maria Roche's comment here to highlight the fact that this sample skews toward larger firms in comparison with the earlier E.U. survey. In her view, the results reported here likely understate the value of OSS to smaller firms, which is quite consistent with the results reported in the E.U. study (2021).

8 As Stephen Walli has observed, companies' estimates of these counterfactual costs are likely understating the actual time and cost that these companies would require to replace the OSS functionality, in part because the companies assume that they have idle software developer capacity to immediately start the project. If they lack this capacity and instead need to hire additional resources, that additional cost and time would increase the actual cost to replace the functionality.

9 However, this greater precision is at least partially offset by the reduction in the number of respondents, as this question required a level of detailed knowledge that many respondents simply did not possess.

10 As commentator Nithya Ruff has observed, it is difficult for companies to measure quantitatively the value of allowing their employees to give back to the underlying code base. This likely limits the extent of such support for the OSS code.

11 As Melissa Evers commented, firms that rely on OSS take on the risky assumption that there will be committed maintainers for the code because adopters of OSS are highly dependent on that maintenance being supplied going forward.

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Founded in 2021, Linux Foundation Research explores the growing scale of open source collaboration, providing insight into emerging technology trends, best practices, and the global impact of open source projects. Through leveraging project databases and networks, and a commitment to best practices in quantitative and qualitative methodologies, Linux Foundation Research is creating the go-to library for open source insights for the benefit of organizations the world over.

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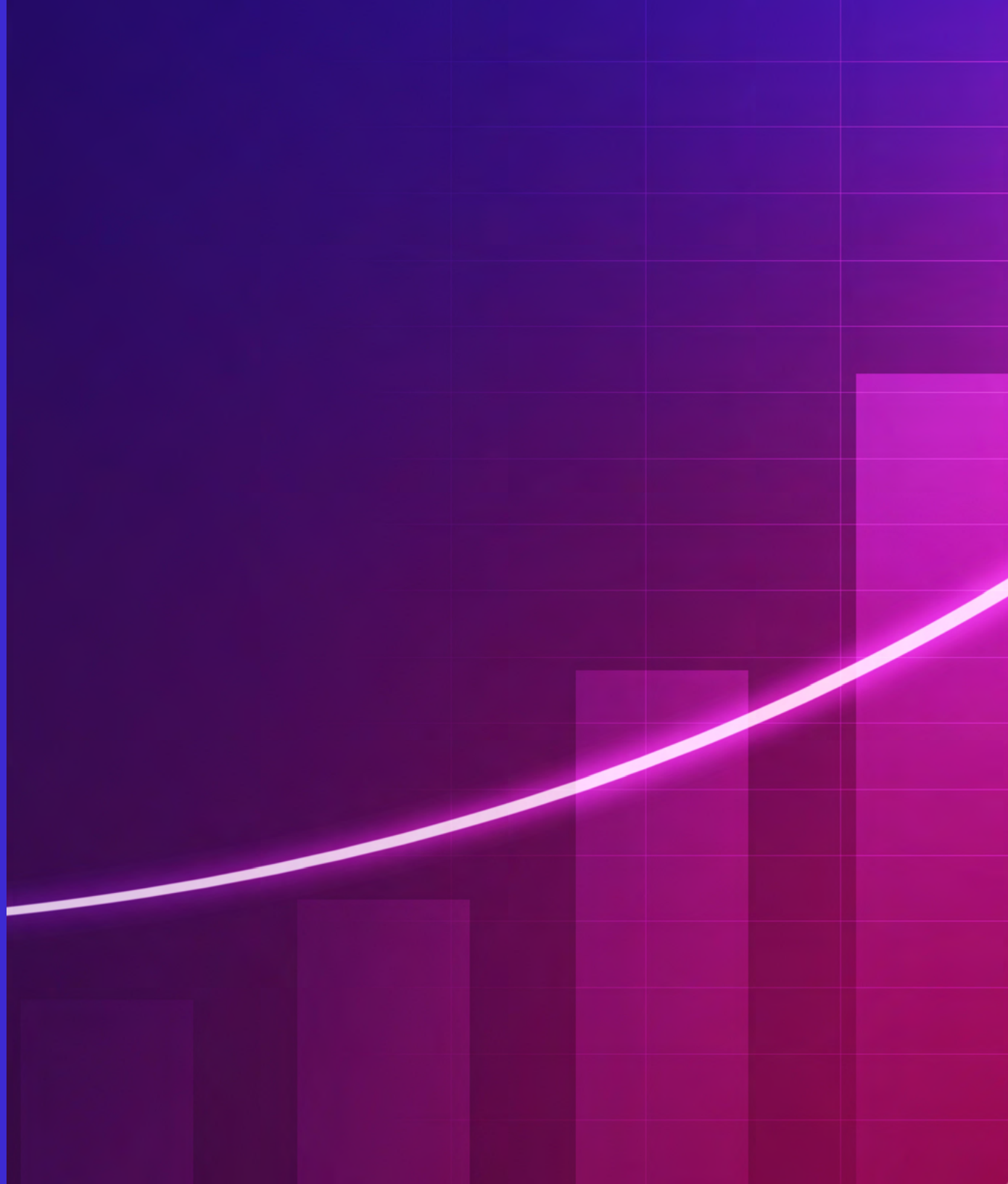
To reference this work, please cite as follows: Henry Chesbrough, "Measuring the Economic Value of Open Source: A Survey and a Preliminary Analysis," foreword by Irving Wladawsky-Berger, The Linux Foundation, March 2023.