FACTORS AFFECTING OPEN SOURCE SOFTWARE ADOPTION

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Abstract

Open-Source software adoption has seen an uptick in the past few years. OSS comes with the advantage of development flexibility and cost-effectiveness and disadvantages like lack of adequate support and uncertainty in quality. The presence of both significant benefits and challenges decides to adopt OSS solutions difficult. Existing research lists down the factors being considered by organizations while deciding to adopt the OSS solution. This paper expands on existing research by recommending a decision-making framework to assist in determining whether to adopt an open-source software or not.

Introduction

Open-Source software are software solutions that copyright holders of the solution have made publicly accessible and free to examine, alter use, and share.

Open-source software adoption benefits organizations in the following ways: -

1. Secondary innovation: Open source provides organizations the flexibility to customize the technology being adopted to their own needs. This enables them to innovate beyond the initial intended scope of the technology being adopted.
2. Low cost of adoption: Ajila et al (2007) reports that open-source software saves cost while improving the overall productivity of the organization using them. Open-source software gives organizations an opportunity to experiment and fail fast without a significant financial cost.
3. Time-to-Market: da Silva et al (2017) studied OSS adoption intentions and determined that shorter time to market was seen as a key advantage of adopting Open-source software.

Open-source adoption has its fair share of challenges as listed below: -

1. Lack of support: Open-source adoption can occasionally present a steeper learning curve due to the lack of expert support in the development phase. Vendor-based enterprise software provides a developed ticketing mechanism for raising concerns and has standard procedures in place for resolving client queries. Open-source solutions often rely on the community of open-source users to resolve queries which leads to unpredictable resolution times for any concerns raised. Steinmacher, I. et al (2015) studied OSS adoption barriers and found that 75% of their studied reports cited the socialization aspect of OSS as an important challenge in OSS adoption.

2. Difficulty in solution maturity assessment: Limited headway has been made in finding a way to understand the maturity level of an open-source solution and the quality of code in the solution. A proxy would for the maturity assessment for open-source software available on GitHub could be the number of forks of the code repository or the number of stars given to it.

Glynn et al (2005) report that the most significant obstacle to adopting an open-source solution is the existence of a planned IT system and infrastructure based on proprietary software.

The trade-offs in open-source adoption thus impose a decision-making dilemma on organizations pertaining to the adoption of open source. Many researchers have tried to study the factors responsible for adopting an open-source technology in an organization. Sanchez et al (2020) have done an extensive analysis on different factors and combined the results in a concise manner. However, which factor becomes the most important and in what context and geography is missing. Therefore, in this report, we present our findings on the factors which are most important for the organizations to adopt open-source software in each geography and industry. This study will help open-source software developing organizations to decide the kind of product that they should launch, the geography that they should launch it in, and the customer segment (industry) that they should be targeting. Moreover, it would be recommended a model for decision-making on open-source adoption.

Literature Review

As per Sanchez et. Al. (2020), organizations typically decide whether to adopt an open-source software based on three factors viz. technological, organizational, and economic.

Technological factors define the technical traits and challenges that would be faced while adopting the software. These factors are:

1. Compatibility: This factor refers to the compatibility of the data formats used in an organization with the open-source software adopted. Rossi et al (2012) report that a municipality canceled its migration to an open-source software just because the software didn't support the format of the organization's legacy documents.
2. Reliability: This factor refers to the number of errors/bugs encountered during the usage of the software. The lesser the number of bugs encountered, the greater are the chances to adopt the software. For example, Android is adopted by nearly 1300 brands worldwide (Android, 2021) because of its reliability.

3. Usability: This factor refers to the ease of usage of the software. Organizations want easier software to reduce training overheads.
4. Customization: Customization refers to the level of personalization allowed in the software adopted. Agile organizations require their software to be flexible to meet their day-to-day needs and hence focus a lot on the personalization aspect.
5. Documentation: Documentation goes along with usability. It refers to the quantity and the quality of documentation available for the software. Lack of documentation increases costs in the form of training internal employees and hiring external IT consultants for assistance.
6. Maintainability: Maintainability refers to the number of resources required to keep the software usable including updates, new features, and improvements on the software.
7. Trialability: Trialability answers the question of "how easy is it to install and integrate the software with the current system?" For example, many software such as OpenOffice has a downloadable version to try, which is easy to install.
8. Reusability: This factor refers to how much amount of the code of open-source software can be reused. IT companies regularly upgrade their codebase on a preexisting code instead of writing everything from scratch and hence prefer reusable solutions.
9. Portability: Portability refers to where all the software can be ported and hence used. For example, Mozilla Firefox is a great software in this sense since it can be ported to all kinds of operating systems viz. Windows, iOS, Linux.

Organizational factors define the organizational aspects such as the support provided and the human resources aspects such as the training provided, while economic factors measure the cost-effectiveness of adopting the software. More exhaustively, these factors are:

1. Organizational support: This refers to the IT support given by the organization in due course of running the software and in adopting it. It also includes management's attitude towards adopting open-source software. As reported by Marsan et. Al. (2013), lack of IT support can jeopardize the adoption of the technology. Ramdani et al (2007) argue that without management backing, users feel more reluctant to adopt a new technology.
2. Training: This refers to the resources and the actions taken by an organization to overcome skill barriers in adopting a new technology. Rossi et al (2012) interviewed various managers in organizations that confirmed that training is important for an acceptance of a new technology.

3. Time taken to adopt: This factor refers to the time that an organization will take to adopt a solution. If the time taken is large, the decision to adopt may be affected.
4. Centrality of IT: This factor refers to how much an organization is dependent on its internal IT infrastructure. If the organization is highly dependent on the said replaceable system, the decision may be affected.
5. Business process re-engineering required: This factor refers to the scenario when an organization is undergoing internal changes in its business processes and hence requires a new IT infrastructure to support the organization.
6. Cost-effectiveness of the technology (Economical factor): This refers to the cost that may be saved by adopting a certain technology in a long run. It measures whether adopting a technology would make financial and economic sense.

Sarrab et al (2014) recognized the system, service, and information quality of the OSS solution to be adopted as decision-making criteria for adoption, thus limiting itself to the quality of the solution. Ven et al (2008) explored the considerations organization make while adopting open source and pointed out that claims exist for and against the same characteristics of open source. For example, some claim that source course availability leads to higher cold quality while others claim they do not. This can be attributed to the capabilities and characteristics of the organization itself differing. Hence the decision-making criteria for OSS adoption will vary based on the characteristics and capabilities of an organization.

Red Hat (2021) explored the usage of Open Source by interviewing 1250 leaders in IT and reported that higher-quality software, access to the latest innovations, and improved security as the top three reasons for adopting enterprise open source. The report identifies the level of support available, compatibility of the software, and security of the code as the top three challenges to adopt open source. The study can be extended by covering the financial implications of open-source adoption along with organizational implications.

D Macredie et al (2011) developed a framework for open-source adoption factors in SMEs (Small and Medium Enterprise). The framework concludes that the main factors responsible for the adoption are organizational attitude, subjective norms in an organization and its external environment, and perceived control of an organization on its IT infrastructure.

As a very specific use case, Johnston et al (2013) studied the factors responsible for open-source software adoption within the education system in South Africa. Their

study found that the most important factors in favor of adopting were cost, positive attitude of the concerned stakeholders while compatibility and lack of resources and support are the most important factors negatively influencing the shift.

Research Methodology

The research was done with the following goals in mind: -

1. Understanding the common industry applications of the Open-Source Software
2. Understanding the factors being considered by decision-makers while adopting open-source solutions
3. Understanding a developer's perspective of Open-Source Solution
4. Building a priority list of adoption factors based on their importance

Following activities were conducted for the research: -

1. Secondary Research: The goal of secondary research was to list down a broad set of factors that are being considered before adopting open-source software. A literature review of research papers on the topic and reports by reputed open-source organizations like Red Hat was conducted.
2. Primary Research: Primary research was used to understand the common industry applications of open source and priority organizations give to different factors affecting OSS adoption. A survey was taken of people holding decision-making positions at software divisions of different industries. A survey conducted had the following structure: -

    a. Respondent Employer Details: Gather information about the industry the employer exists in and the scale of its operations.
    b. Organizational Factors: Understand the importance respondents give to different organization considerations that would have to be considered while adopting open-source software. Importance rated on a Likert scale with values ranging from 1-7.
    c. Technology characteristics: Understand the importance respondents give to different characteristics of the open-source technology they are planning on adopting. Importance rated on a Likert scale with values ranging from 1-7.

Results

Overall high-level results

As can be seen from figure 1, “Time taken to adopt” and “Cost-effectiveness” of an open-source software come out to be the most important factors for organizations. “Training” comes out to be the least important factor for adoption. For all these organizations, IT is highly central with an importance score of 6.56 out of 7.

Figure 1: Importance scores of organizational factors (out of 7)

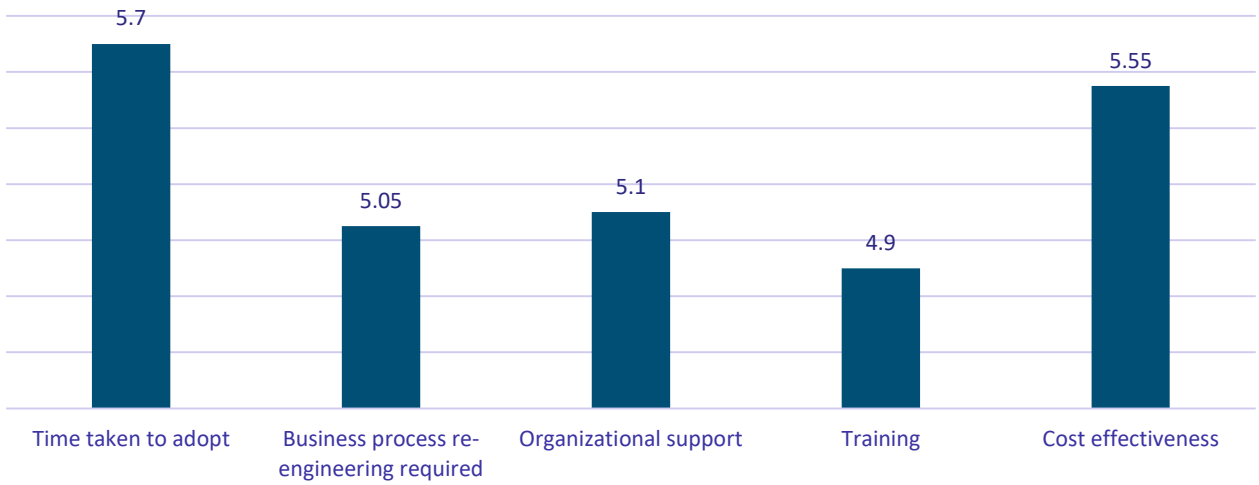
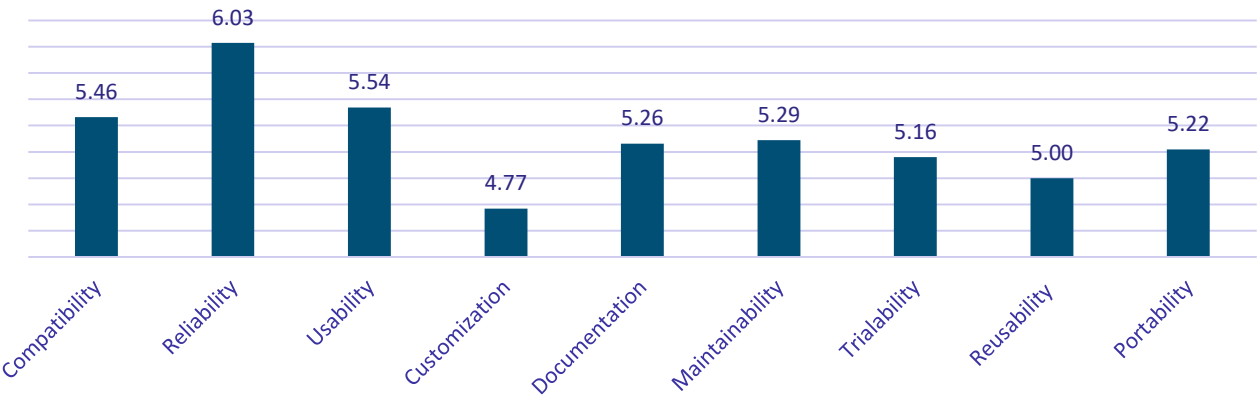


Figure 2 shows us that “Reliability”, “Usability”, and “Compatibility” of the open-source software are the most important factors to decide whether to adopt the technology or not. “Customization” and “Reusability” are the least important technological factors overall.

Figure 2: Importance scores of technological factors (out of 7)



Region-based results

We have divided the organizations into two categories:

1. Local: These are the organizations whose products run only locally (within a country).
2. Global: These are the organizations whose products/services are offered globally.

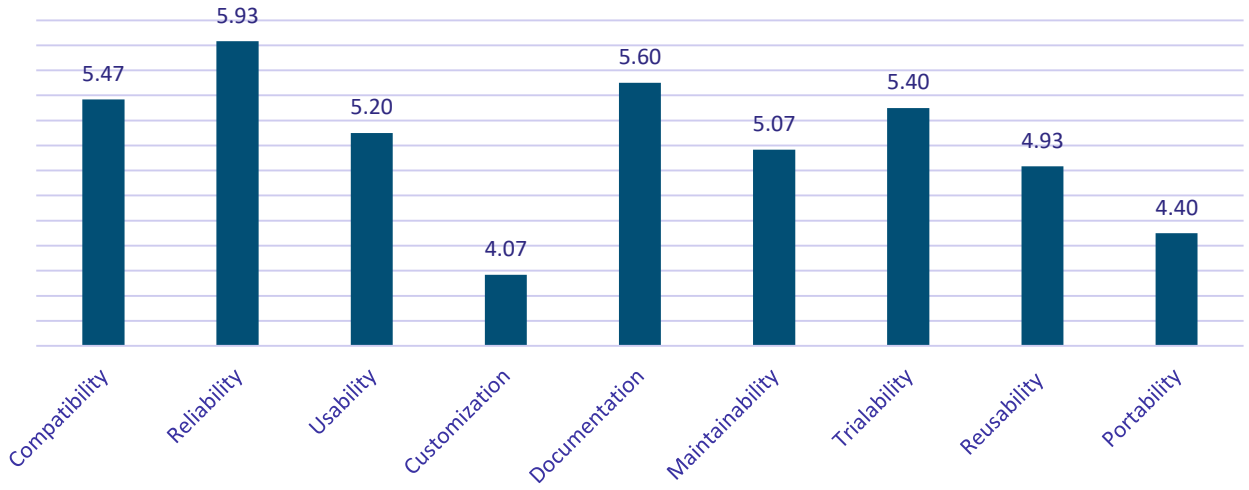
Local firm results

For all "local" organizations, IT is highly central with an importance score of 6.53 out of 7. As can be seen from figure 3, "Time taken to adopt" and "Cost-effectiveness" of an open-source software come out to be the most important factors for local organizations. "Business process re-engineering required" comes out to be the least important factor for adoption.

Figure 3: Importance scores of organizational factors for organizations operating locally (out of 7)

Figure 4 shows us that "Reliability", "Documentation", and "Compatibility" of the open-source software are the most important factors to decide whether to adopt the technology. "Customization" and "Portability" are the least important technological factors for local firms.

Figure 4: Importance scores of technological factors for organizations operating locally (out of 7)



Global firm results

For all "local" organizations, IT is highly central with an importance score of 6.57 out of 7. As can be seen from figure 5, "Time taken to adopt" and "Cost effectiveness" of an open-source software come out to be the most important factors for local organizations. "Training" comes out to be the least important factor for adoption.

Figure 5: Importance scores of organizational factors for organizations operating globally (out of 7)

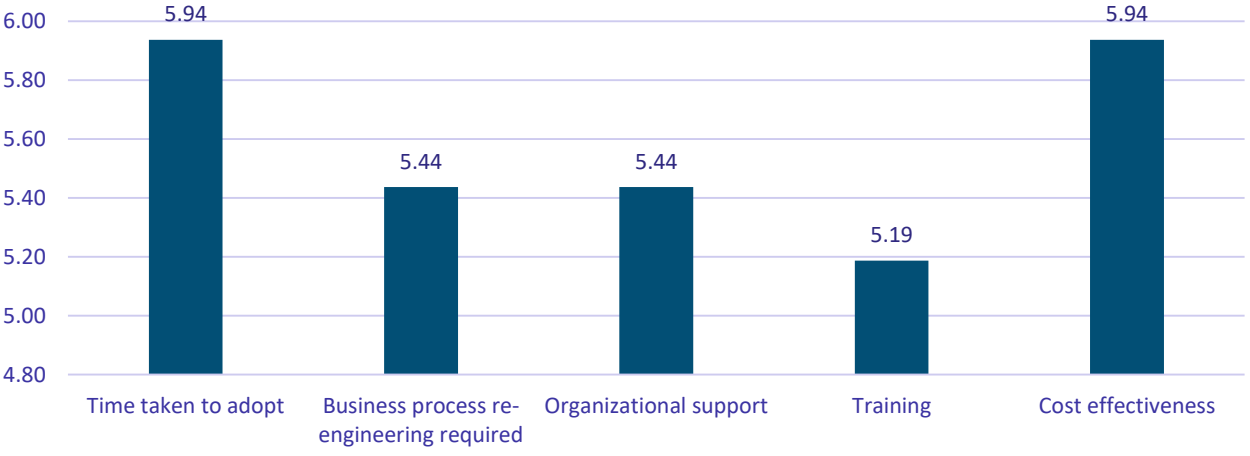
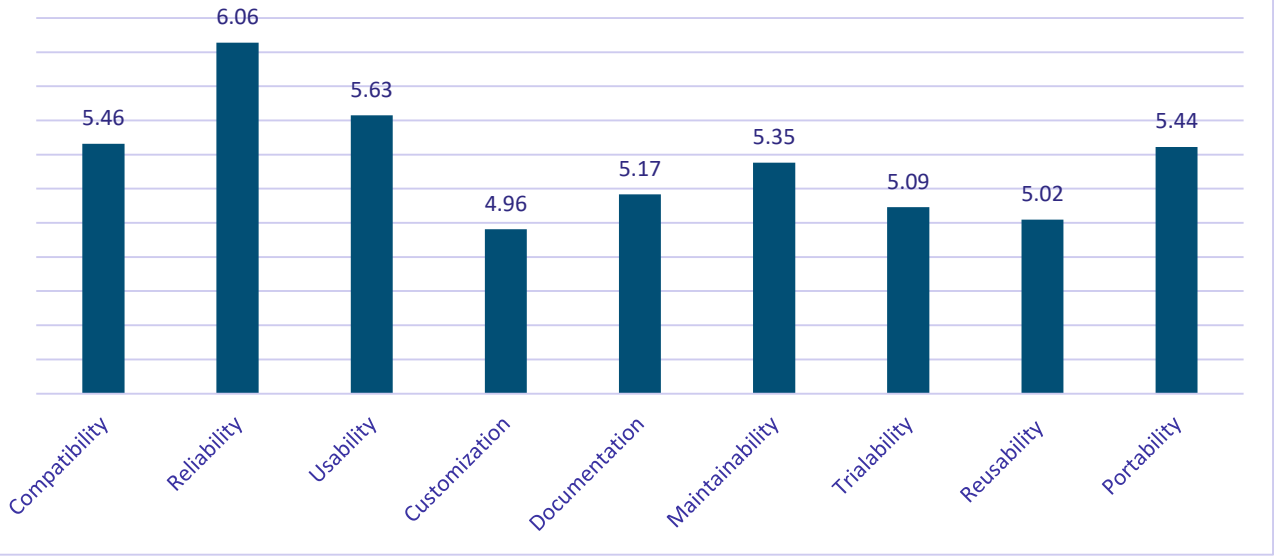


Figure 6 shows us that "Reliability", "Usability", and "Compatibility" of the open-source software are the most important factors to decide whether to adopt the technology.

"Customization" and "Reusability" are the least important factors for global organizations.

Figure 6: Importance scores of technological factors for organizations operating globally (out of 7)

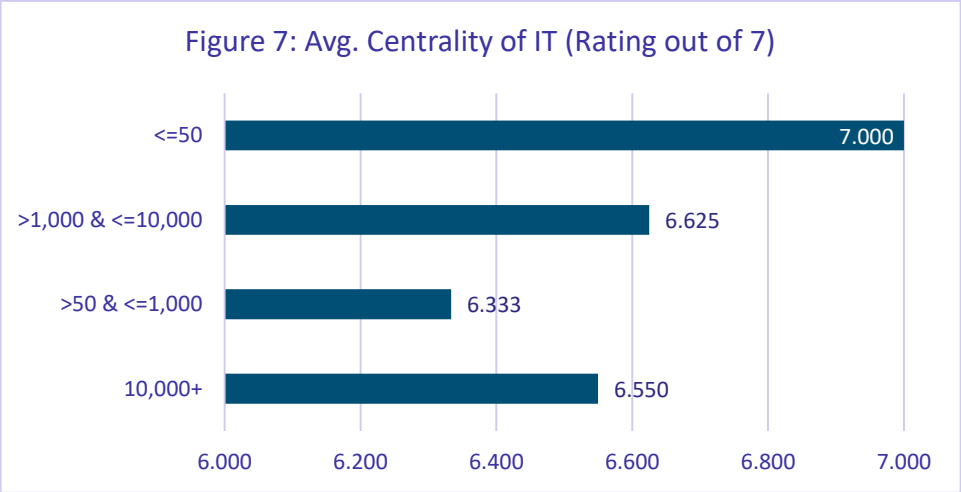


Company Size Based Results

The majority of the respondents worked for a larger firm with a number of employees higher than 10,000. (Responded split given in Exhibit 2)

Centrality of IT

As indicated in figure 7 given below, smaller firms rated centrality of IT 7 out of 7 indicating the trend that smaller firms are increasingly depending on information systems to gain efficiencies to be competitive in the market.



Implementation Use Cases

A high % of companies use Open-Source Software for application development (Web or Mobile). This can be attributed to Angular (open-source web application framework) becoming the industry standard for application development. Open-source solutions have low adoption in use cases, like data analysis and deep learning, where access to sensitive data is required. Smaller companies (<=50 employees) rely on Open Source for most use cases while the largest companies rely on OSS for the least number of use cases as a larger employee base gives them an opportunity to build more in-house solutions, while higher cash flows would allow them to pay for software offered by vendors

Table 1: % Respondents using OSS for a use case by organization size

Size	10,000+	>50 & <=1,000	>1,000 & <=10,000	<=50
Advertising	2.50%	0.00%	0.00%	0.00%
App Dev	65.00%	77.78%	81.25%	100.00%
Communication systems	27.50%	22.22%	18.75%	66.67%
IT Infrastructure	0.00%	0.00%	6.25%	0.00%
Office automation	37.50%	33.33%	43.75%	33.33%
Open-source deep learning models and libraries	2.50%	0.00%	0.00%	0.00%
Operating systems	30.00%	33.33%	56.25%	66.67%
Project management systems	32.50%	33.33%	18.75%	33.33%
Data Analytics	2.50%	11.11%	0.00%	0.00%
Avg. Total Applications Use Cases	2.950	3.889	3.813	6.000

Adoption Factors

Large companies (1,000+ employees) expect open-source solutions they are planning to adopt to be Reliable and easy to use. Relatively smaller companies, value open-source solutions that are reliable, have good documentation quality, and are easy to use.

Table 2: Importance scores of technological factors by organization size (out of 7)

Technological factor	10,000+	>50 & <=1,000	>1,000 & <=10,000	<=50
Compatibility	5.50	5.56	5.19	6.67
Customizability	5.20	5.22	4.19	1.67
Maintainability	5.45	5.22	5.00	5.67
Portability	5.35	5.78	5.13	3.00
Documentation	5.35	5.78	4.63	6.33
Reliability	6.30	6.22	5.38	6.00
Reusability	5.20	5.00	4.44	6.00
Trialability	5.18	5.22	5.06	6.33
Usability	5.75	5.22	5.31	5.67

When it comes to organizational factors (given in the table below), the cost-effectiveness of technology and the time taken to adopt the technology is unilaterally important across companies of all sizes. Most companies do not value the availability of training on the technology used more than other factors as adequate documentation could replace the need for explicit training in the usage of the solution.

Table 3: Importance scores of organizational factors by organization size (out of 7)

Organizational factor	10,000+	>50 & <=1,000	>1,000 & <=10,000	<=50
Training	5.125	4.500	5.143	3.000
Support	5.000	6.000	4.714	5.000
Cost-effectiveness	6.250	6.000	4.286	7.000
Business process re-engineering required	5.250	6.000	4.286	5.000
Time taken to adopt	5.875	5.750	5.286	7.000

Industry based results

The split of the industry respondents' employers operate in is given in Exhibit 2. Finance and IT, due to their prevalence amongst the respondents, are the segments being analyzed in the following segments. Both the industries have a high degree of centrality of IT in the business as indicated by Exhibit 3.

Implementation use cases

Application development is the primary use case for open-source solutions in both industries

Table 4: % Respondents using OSS for a use case by industry

Use Case	Financial Services	Information Technology
Advertising	0.00%	2.17%
Analytics	0.00%	2.17%
App Dev	80.00%	73.91%
Communication systems	40.00%	28.26%
IT Infrastructure	0.00%	2.17%
Office automation	50.00%	32.61%
Open-source deep learning models & libraries	0.00%	2.17%
Operating systems	40.00%	41.30%
Project management systems	50.00%	26.09%
Data Analytics	0.00%	2.17%
Avg. Total Applications	3.800	3.522

Adoption Factors

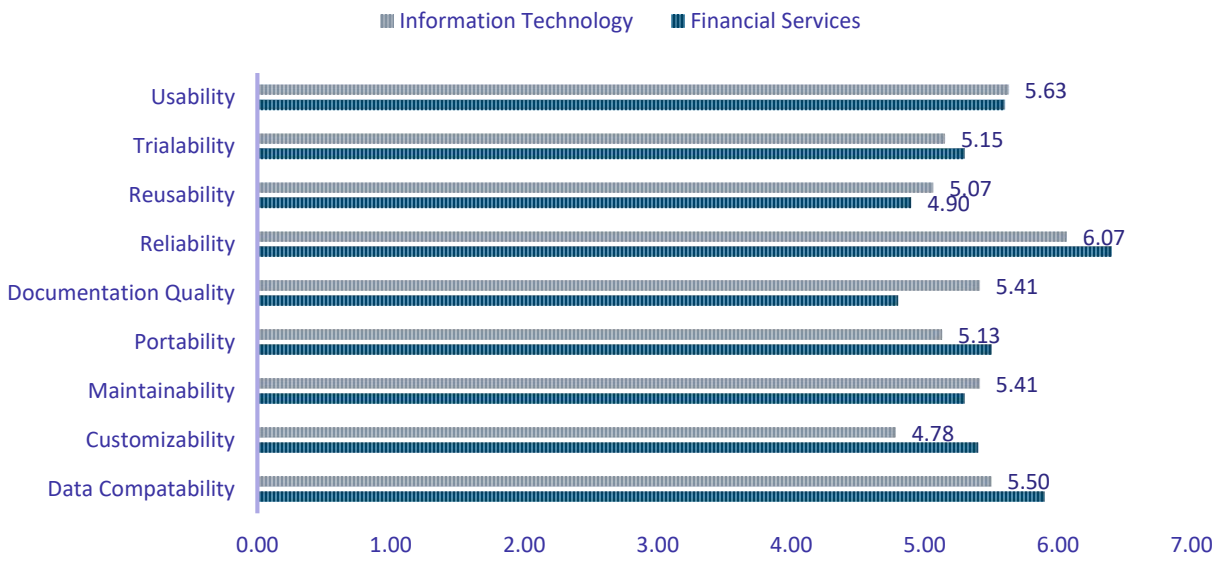
Financial services value solutions that are cost-effective. They expect the solution to have a quick implementation period and to have adequate post-adoption support. Whereas Information Technology firms just want the solutions to be cost-effective, to maximize margins, and low adoption time.

Table 5: Importance scores of organizational factors by industry (out of 7)

Organizational factor	Financial Services	Information Technology
Training	5.667	5.071
Support	7.000	4.786
Cost-effectiveness	6.333	5.500
Business process re-engineering required	6.000	4.786
Time taken to adopt	7.000	5.500

Reliability of the solution offered is the primary concern for both the financial and IT industries. The compatibility of available data with the solution is of importance to the financial services industry. Whereas ease of use of the technology is important for the IT industry.

Figure 8: Importance scores of technological factors for organizations by industry (out of 7)



Recommendations

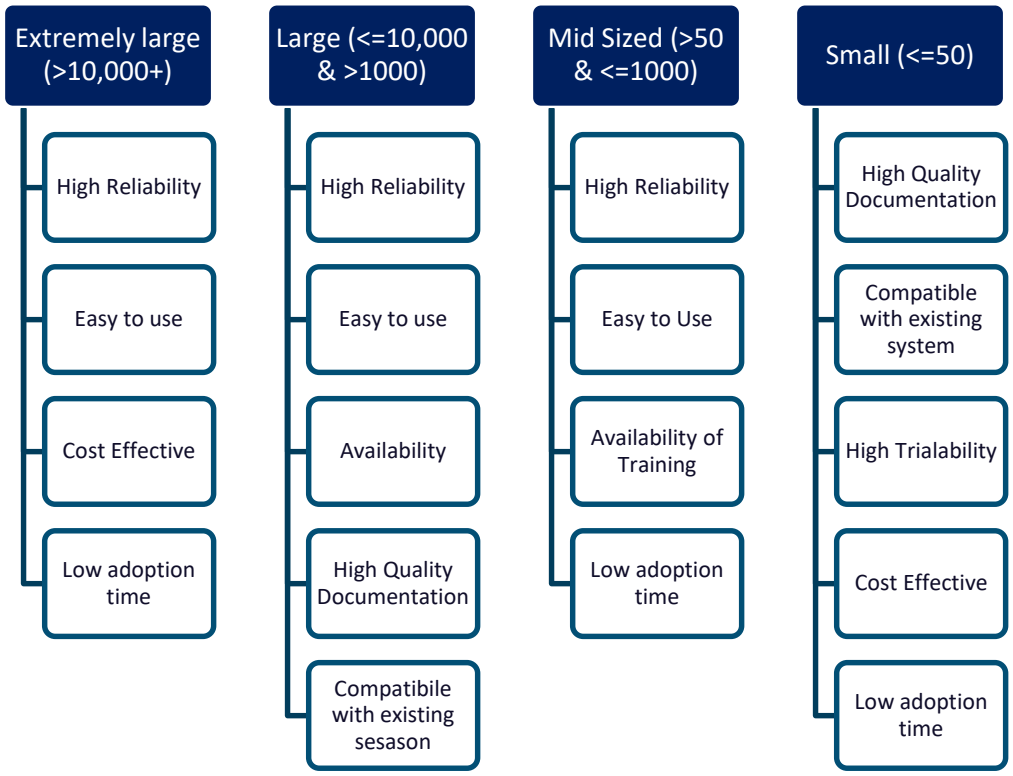
Overall, we recommended that an ideal solution that would provide the most value to an organization must be cost-effective, reliable, compatible, easily usable, and take less time to adopt.

We also propose recommendations based on two different cuts:

1. Based on a regional scale of operations (Global and Local)
2. Based on organization size (Small, Mid-sized, Large, Extremely large firms)

Recommendations based on Regional Scale of Operations

Recommendations based on Organization Size (Number of employees)



Recommendations based on a combination of the regional scale of operations and organization size (Number of employees)

Combining the scale of operation and size of the firm, it is recommended for an organization to adopt the open-source software that has the characteristics in accordance with the table given below.

Table 6: Recommendations for organizations based on the scale of operation and size

	Small	Mid-sized	Large	Extremely large
Global	Quick adoption; Cost-effective; Compatible	Cost-effective; Reliable	Quick adoption; Reliable; Easily usable	Quick adoption; Cost-effective; Reliable; Easily usable
Local	Quick adoption; Cost effective; Documented; Compatible	Cost effective; Reliable; Documented	Quick adoption; Reliable	Quick adoption; Cost effective; Reliable

Future scope of the study

1. Geographically diverse views: Currently, a vast majority of views taken are from professionals and leaders from the Indian subcontinent. A geographically diverse view would help to capture cultural and regulatory differences as well, thereby giving a more holistic picture.

2. Industrially diverse views: In our study, a vast majority of responses are taken from people working in either the information technology (IT) sector or the financial sector. Taking views from a variety of industries would help in aiding the digital transformation across industries.

3. Use-case based factors: Studying factors based on the use cases on which these open-source solutions have been adopted would help the organizations in their decision

4. Analysis for more combinations: Studying factors across the different segment and cut combinations such as firm size and use cases, geography and use cases, etc. would give a more holistic picture to the organization

Appendix

Exhibit 1: Survey

1. What industry would you say your company belongs to?
    a. Financial Services
    b. Manufacturing
    c. Pharmaceutical
    d. Information Technology
    e. Consulting
    f. Marketing
    g. Other
2. What is the size of your company (no. of employees)?
    a. <=50
    b. <=1,000
    c. <=10,000
    d. 10,000+
3. In what applications, have you, your company, or your department adopted OSS (Open-Source Software)? [Select 1 or more]
    a. Office automation
    b. Web designing
    c. Content management systems
    d. Operating systems
    e. Communication systems
    f. Mobile application development
    g. Desktop application development
    h. Project management systems
    i. Other
4. How central is information technology to the functioning of your organization? The rate on a scale of 1-7 (1-Not central at all, 7-very central)

Organizational Considerations

How important are the following factors (on the scale of 1-7, 7 being most important) for the adoption of OSS in your organization?

1. Time taken to adopt the technology

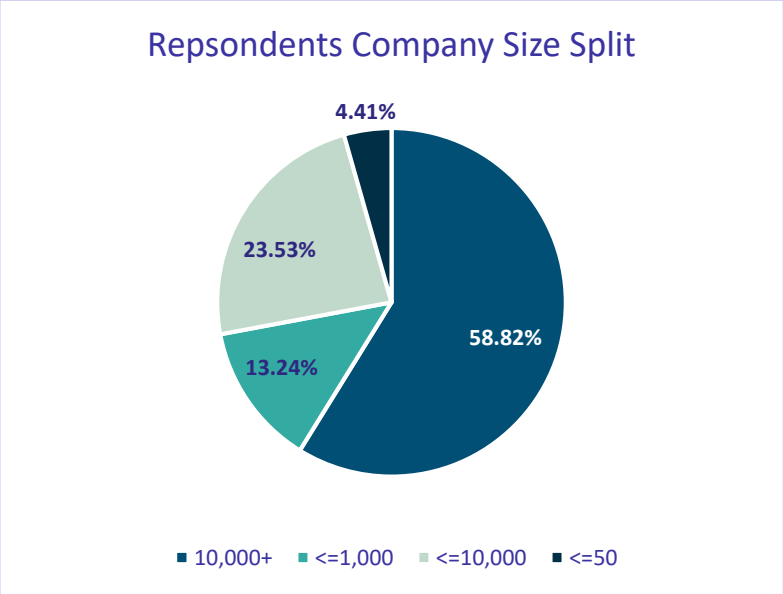
2. Extent of Business process re-engineering required
3. Availability of adequate post-adoption support
4. Availability of adequate training on how to use the technology
5. Cost-effectiveness of the technology

Technological Considerations

How important are the following factors (on a scale of 1-7, 7 being most important) for the adoption of OSS in your organization?

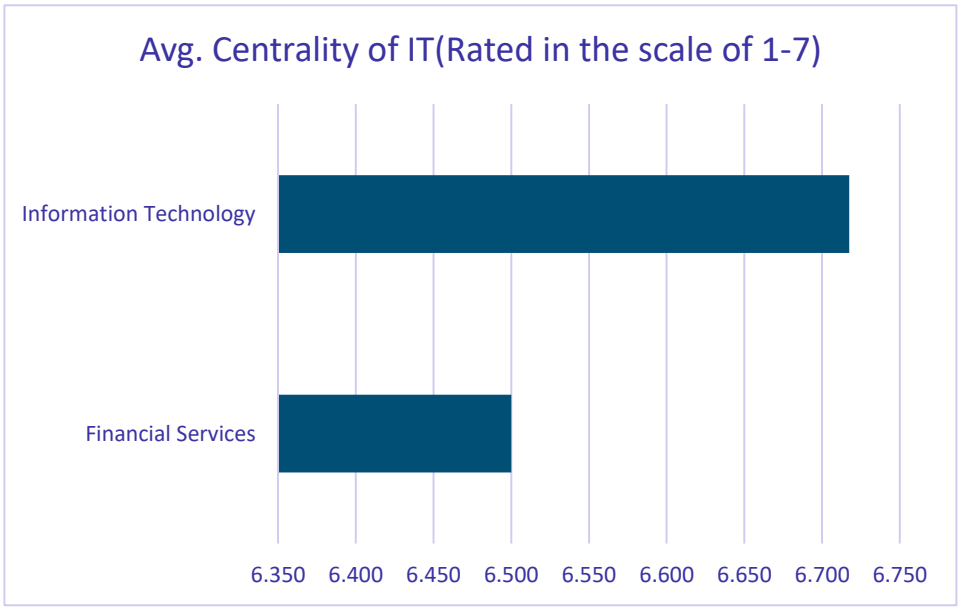
1. Compatibility with regards to the data formats
2. Reliability (number of bugs encountered during usage)
3. Usability (ease of usage)
4. Customization (degree of personalization allowed)
5. Quantity and quality of documentation available
6. Maintainability (amount of resources required to maintain)
7. Trialability (ease to install and integrate)
8. Reusability (amount of code that can be reused)

Exhibit 2: Survey Respondent Split



Industry	Share
Information Technology	67.65%
Financial Services	14.71%
Manufacturing	2.94%
Consulting	2.94%
Travels	1.47%
Telecommunications	1.47%
Oilfield services	1.47%
Marketing	1.47%
Food tech	1.47%
Education	1.47%
E-Commerce	1.47%
Business Intelligence	1.47%

Exhibit 3: Centrality of IT by industry



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