Mathematical Model for Open Source Software (OSS) Adoption in Pakistan

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Abstract

OSS (Open Source Software) is the emerging technology, which is popular for its cost saving factor. OSS is a software that is usually available without charges and that all individuals are free to modify. Pakistan IT industry is also trying to get benefits from this technology. This paper proposes a framework for OSS adoption in Pakistan and its implementation. On the basis of the framework a mathematical model has been proposed. By using this model companies can estimate their adoption threshold for OSS adoption. A threshold value gives the rate or decision point on which a company can decide to migrate toward OSS or not. Further the given model implementation in an organization is discussed as a case study.

1. Introduction

Open source software has gradually made its way across the shores of Pakistan. OSS products have started to develop in more visible applications such as desktop applications for word processing, spreadsheet, email, etc. In order to achieve cost effective solutions and evade piracy many organizations are willing to migrate to OSS. Therefore the need of model for OSS Adoption has become more desirable, model should also provides threshold value which can help in taking decision to adopt OSS in an Organization.

Open source software is a software for which the source code is distributed along with the executable program which can be accessible via Internet without charge or limitations on modifications and future distribution by third parties. Open Source Software (OSS) has seen extraordinary success since the term was introduced in 1998[1].

The open-source or free-software movement took off in 1985 by Richard as a reaction or frustration against proprietary software and closed-source commercial software (CSS) monopoly of hiding the source code from user. To diminish the CSS atmosphere Stallman founded the ‘Free Software Foundation’ (FSF) to develop and distribute software under the General Public License (GPL) that allows the notion of freely sharing one’s work as a matter of principle [2].

The paper is structured as follows: In the next section, framework for OSS adoption in Pakistan is provided in relation to model followed by section 3 which discusses the mathematical model and then section 4 which presents threshold value calculation. Section 5 explains the implementation of the model in an organization as a case study. Section 6 provides a discussion of the results with the conclusions. Finally section 7 identifies the directions for future research.

2. Framework For OSS Adoption In Pakistan

It is sought to understand why organizations adopt open source software, for this a framework has been proposed which contains rich set of technological, organizational, environmental and individual factors that influence such decisions. This framework is inspired by a previous work done by Exton C[3] and also have some influences of the work provided by Kenwood C [4].

For framework design an investigation study was conducted to find out the factors behind the adoption of OSS. The majority of organizations working in Karachi with a stable IT department and diverse area of operations like construction companies, bank, education, service, communication etc are included in this research survey to allow an in depth study. The names of the organizations are not mentioned due to confidentiality.

Formal discussions were conducted to obtain in depth information on how to promote OSS use, what constraints could be overcome and possible future directions were sought. Based on the estimates and the actual number of completed interviews the response rate was calculated to be 75%. The total sample size was 60 out of which 45 were usable responses. On the basis of market survey probabilities of different factors of model were calculated which will be used in section 4.

Figure 1 illustrates all the factors which contribute positively or negatively in OSS Adoption[3,5]. Each of the factors which inclined toward increase in the degree of adoption are marked with (▲) while other factors which are negative for the adoption of OSS are marked with (▼).

Where
(▲). Positive Factors.
(▼). Negative Factors.

Main factors are explained as below.
2.1 Intrinsic Factors

Intrinsic factors are identified as the factors that emphasize on the needs of an organization for being adequate for OSS adoption. It includes the organizational internal affairs like top management support for adoption, availability of OSS literate IT staff and greater saving possible by using OSS.

2.2 External Factors

Awareness is the critical enabler in the OSS adoption because if people are aware of the technological benefits of OSS then they might think about adoption. Open source software adoption requires government support and grants for proper execution.

Although piracy is the main issue, OSS adoptions evade piracy, which is a sign of honor. The lower cost of OSS, evades piracy which is the major issue in Pakistan.

2.3 Individual Factors

Individual factors are identified as those factors that emphasize on the need to expand the focus of OSS adoption at individual level. Individual factors are also important for OSS acceptance in Pakistan because if people favour OSS then they definitely go for OSS adoption [3].

2.4 Technological Factors

Technological factors highlight those factors that emphasize on the needs of organization technological prospective for adopting new technology. The basic issue in adopting a technology is training. Although most OSS applications, user-interface and functionalities are similar to the proprietary software like Microsoft applications but still there are some differences that hamper the use of OSS.

![Figure 1. Factors for OSS Adoption in Pakistan](image-url)
3. Mathematical Model

The proposed framework is used to derive the following equations which are used for OSS migration threshold value calculation.

The framework is divided into four major factors, therefore the basic equation also consists of four main equations. These four equations manipulate adoption threshold by addition.

Weights are assigned to each factor based on their importance. All the weights have been assigned according to the software engineering trends and under the assumption that dependency can be expressed as a linear combination, which means that non-linear or crossed continuation being negligible and has been ignored.

The most important factor that an organization must consider before migration toward OSS is Intrinsic factors because if top management decides to go for OSS than other factors are of no importance i.e. individual, external or technological factors [3,5].

Comparing individual, external or technological factors it is safe to consider external factors first than technological factors and finally individual factors. The reason of giving individual factors low priority is because usually employees wish is neglected. If an organization keep the above factors according to the given importance level than it is safe to predict that adoption will be smooth and beneficial.

Adoption Threshold=(\(W_x\) I)+(\(W_y\) E)+(\(W_z\) IN)+(\(W_y\) T)

Where
\(W_x=50\), weight assign to Intrinsic factors
\(W_y=10\), weight assign to Individual factors
\(W_z=20\), weight assign to External factors and Technological factors
\(W_y\) is high because for Adoption if an Organization is willing toward migration and if the individual, external or technological factors are not in their favour that they can adopt OSS in their Organization. Rests of the weights are assigned according to their importance.

I=Intrinsic Factors,
E=External Factors,
IN=Individual Factors,
T=Technological Factors.

Intrinsic factors are the basic factors included in migration process. Its equation is as follow

Intrinsic Factors (I) = (\(W_x\) EF)+(\(W_y\) OF) (2)

Where
\(W_x=25\), weight assign for Economical Feasibility and Operation Feasibility,
EF=Economical Feasibility,
OF=Operation Feasibility.

Economical Feasibility (EF) = (\(W_y\)EF)+(\(W_z\)EF) (3)

Where
\(W_y=15\), weight assign to Low Cost factor,
\(W_z=10\), weight assign to TCO,
\(\text{B}\) = Probability of Low Cost,
\(\text{B}\) = Probability of Total Cost of Ownership.

Operation Feasibility (OF) = (\(W_x\)PO)+(\(W_y\)PO)+(\(W_z\)PO) (4)

Where
\(W_x=3\), weight assign to Organization Size,
\(W_y=4\), weight assign to Unstable IT infrastructure,
\(W_z=6\), weight assign to Top Management Support, Skilled staff and External Service Providers,
PO = Probability of Unstable IT infrastructure,
PO = Probability of Organization Size,
PO = Probability of Top Management Support,
PO = Probability of Skilled staff,
PO = Probability of External Service Providers.

External Factors (E) = (\(W_x\)PE)+(\(W_y\)PE)+(\(W_z\)PE) + (\(W_x\)PE)+(\(W_y\)PE)+(\(W_z\)PE) (5)

Where
\(W_x=3\), weight assign to Awareness, Open Standards, Wide Purchase Agreement and Wide standards for IT,
\(W_y=4\), weight assign to Government Support and Avoid Piracy,
PE = Probability of Awareness,
PE = Probability of Government Support,
PE = Probability of Avoid Piracy,
PE = Probability of Open Standards,
PE = Probability of Wide Purchase Agreement,
PE = Probability of wide standards for IT.

Technological Factors (T) = (\(W_x\) PT)+(\(W_y\) PT)+ (\(W_z\) PT) (6)

Where
\(W_x=3\), weight assign to Training and Functionality,
\(W_y=9\), weight assign to Technological Benefits,
\(W_z=5\), weight assign to Dissatisfaction CSS,
PT = Probability of Technological Benefits,
PT = Probability of Dissatisfaction CSS,
PT = Probability of Functionality,
PT = Probability of Training.

Individual Factors (IN) = (\(W_x\) IN)+(\(W_y\) IN)+(\(W_z\) IN) (7)
Where
\( W_1 = 1 \), weight assign to Non Resistance to Change and Brand Reputation,
\( W_2 = 2 \), weight assign to Anti Microsoft sentiments,
\( W_3 = 3 \), weight assign to Importance to many and Valuable,
\( IN_1 = \text{Probability of Importance to many}, \)
\( IN_2 = \text{Probability of Non Resistance to Change}, \)
\( IN_3 = \text{Probability of Valuable}, \)
\( IN_4 = \text{Probability of Anti Microsoft sentiments}, \)
\( IN_5 = \text{Probability of Brand Reputation}. \)

4. Threshold Value

On the basis of mathematical model threshold value is calculated based on important OSS migration factors. Threshold value is calculated by using the probabilities which are obtained by the results gathered by market investigation. This threshold value can be different for different companies. A value of threshold is calculated 58.47 generally for Pakistan. If any Organization threshold value comes above it than the migration toward OSS is recommended and the organization can get benefits from the adoption.

The calculation of the threshold value is given below.

Using equation 3
\[ \text{Economical Feasibility (EF)} = (15) \times 0.53 + (10) \times 0.58 \]
\[ \text{Economical Feasibility (EF)} = 13.68 \]

Using equation 4
\[ \text{Operation Feasibility (OF)} = (4) \times 0.42 + (3) \times 0.66 + (6) \times 0.71 + (3) \times 0.55 + (6) \times 0.51 \]
\[ \text{Operation Feasibility (OF)} = 14.26 \]

Using equation 2
\[ \text{Intrinsic Factors} = 27.94 \]

Using equation 5
\[ \text{External Factors} = (3) \times 0.31 + (4) \times 0.63 + (4) \times 0.44 + (3) \times 0.41 + (3) \times 0.8 + (3) \times 0.86 \]
\[ \text{External Factors} = 11.46 \]

Using equation 6
\[ \text{Technological Factors} = (9) \times 0.74 + (5) \times 0.41 + (3) \times 0.81 + (3) \times 0.54 \]
\[ \text{Technological Factors} = 12.76 \]

Using equation 7
\[ \text{Individual Factors} = (3) \times 0.73 + (1) \times 0.54 + (3) \times 0.62 + (2) \times 0.81 + (1) \times 0.12 \]
\[ \text{Individual Factors} = 6.31 \]

Using equation 1
\[ \text{Adoption Threshold} = 58.47 \]

Where Adoption threshold value is calculated as 58.47 Companies that are above this rate can adopt OSS while the companies that are below the threshold value are not advice to adopt OSS as shown in the Figure 2.

![Adoption Threshold in Pakistan](image)

5. Case Study Based On Mathematical Model

The Mathematical model of the proposed framework is verified by considering a real working welfare organization refer as ZT. Following are the advantages and factors that are the motivation towards OSS adoption.

5.1 Reasons for Migration

Due to the following reasons, The organization decided to introduce open source software.

5.1.1 Cost Effectiveness

Financial resources are the significant issues in adoption. Funding for the organization comes from the Charity which will be collected from different parts of Pakistan, corporate donors and also from abroad. Charity is being taken in form of cheque, cash and also online charity.

License costs for closed source software are high and it is hard to take per seat based license specially for a welfare organization.

5.1.2 Avoid piracy

System up gradation and license renewal is a problem in the organization because they have to wait for donors. That’s why they have to use pirated software unwillingly.

5.1.3 Compatibility

OSS is compatible with any other program or software that is based on open standards, because of this it is possible for open and proprietary software to interoperable and exchange data. Example the organization receive files from Jang Groups which was incompatible with MS word but compatible with Open Office which have the capability
5.2 Adoption Threshold Manipulation

The threshold value for OSS adoption in the organization is calculated by using the probabilities of factors found their, which are depicted in Table 1.

<table>
<thead>
<tr>
<th>Adoption Factors</th>
<th>Positive Probability(p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance to many</td>
<td>0.83</td>
</tr>
<tr>
<td>Resistance to Change</td>
<td>0.41</td>
</tr>
<tr>
<td>Undervalued</td>
<td>0.27</td>
</tr>
<tr>
<td>Anti proprietary sentiments</td>
<td>0.10</td>
</tr>
<tr>
<td>Brand reputation</td>
<td>0.34</td>
</tr>
<tr>
<td>Low-Cost</td>
<td>0.92</td>
</tr>
<tr>
<td>Total Cost of Ownership</td>
<td>0.73</td>
</tr>
<tr>
<td>Unstable IT infrastructure</td>
<td>0.39</td>
</tr>
<tr>
<td>Organization size</td>
<td>0.43</td>
</tr>
<tr>
<td>Top Management Support</td>
<td>0.93</td>
</tr>
<tr>
<td>Skilled staff</td>
<td>0.44</td>
</tr>
<tr>
<td>External Service Providers</td>
<td>0.23</td>
</tr>
<tr>
<td>Technological Benefits</td>
<td>0.85</td>
</tr>
<tr>
<td>Functionality</td>
<td>0.43</td>
</tr>
<tr>
<td>Dissatisfaction proprietary system</td>
<td>0.23</td>
</tr>
<tr>
<td>Technological Training</td>
<td>0.33</td>
</tr>
<tr>
<td>Awareness</td>
<td>0.46</td>
</tr>
<tr>
<td>Government support</td>
<td>0.54</td>
</tr>
<tr>
<td>Avoid piracy</td>
<td>0.65</td>
</tr>
<tr>
<td>Open standards</td>
<td>0.27</td>
</tr>
<tr>
<td>Wide purchasing agreement with major organization</td>
<td>1</td>
</tr>
<tr>
<td>Industry –wide standards for</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Negative Probability= (1-p)

Using equation 3
Economical Feasibility (EF) = (15)* 0.92+ (10)* 0.73 = 21.19

Using equation 4
Operation Feasibility (OF) = (4)* 0.39+ (3)* 0.43+ (6)* 0.93 + (6)* 0.44 + (6)* 0.23 = 12.48

Using equation 2
Intrinsic Factors (I) =33.68

Using equation 5
External Factors= (3)* 0.46+ (4)* 0.54+(4)* 0.65+(3)* 0.27+(3)* 1+(3)* 1 = 12.95

Using equation 6
Technological Factors = (9)* 0.85+(5)* 0.23+ (3)* 0.43 + (3)* 0.33 = 11.05

Using equation 7
Individual Factors = (3)* 0.83+ (1)* 0.41+ (3)* 0.27+ (2)* 0.10+ (1)* 0.34 = 4.25

Using equation 5.1
Adoption Threshold =61.93

Output of the adoption threshold equation is 61.93 which is greater than the threshold value 58 which conclude that company can have a choice of OSS adoption. This is depicted in Figure 3.

6. Conclusion

This paper has proposed the model through which companies can estimate their threshold value for adoption of OSS. It has shown the success rate of an OSS implementation in an organization that has improved its overall IT budget.

It has been observed that compatibility, skilled staff and maintenance/support are main barriers in proper adoption of OSS. It can be concluded that the organization that are going beyond 58 Threshold value will get full benefits from OSS adoption. Further it can also be concluded by this research that Adoption of OSS will certainly cut cost of softwares used by any Organization and it will also
contribute towards evading of piracy in local environment. People are now starting to understand that the benefits of OSS adoption is far more than the problems that they might face in adopting it

7. Future Work

Further studies are required, to explore OSS development and support in local environment. Developing a better understanding requires discussing it more using different case studies consisting of more complex and advance IT Infrastructure within Organization. For its proper implementation in Pakistan, it will be needed to compare OSS adoption in the local environment with foreign environments, which will be an iterative process due to the rapid changes that are occurring in Pakistani IT Infrastructure

Time by time revision of the proposed model in accordance to the changing IT environment will facilitate in improving the adoption of OSS, which is the need of the current environment.

References