# Organizational Readiness Assessment for Open Source Software Adoption

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Abstract: Open Source Software (OSS) is probably, the most iconic implementation of Open Innovation business paradigm, due its capacity to concentrate both technical benefits and business advantages. Over time, organizations face the OSS adoption challenge strengthening mainly its internal and technical elements. However, the rapid changes on business dynamics, and the comprehensiveness and fast development of open paradigms, show us that a new set of conditions must be satisfied to reach a successfully OSS adoption. These conditions, considered as a critical success factors, involve a wide range of resources, capacities and skills, both in internal and external scopes. Hence, although adopter organizations should be better prepared to face the challenges related to collaborative innovation, they do not have a systematic approach to value its readiness level to face the adoption challenges. In this context, the present research work proposes a model to assess the organizational readiness, considering the adopter as part of a live business ecosystem, where the relationships originated on co-development with developers' communities, have mutual business impact at strategic, tactic, and operative level.

## 1 INTRODUCTION

A successful adoption of Open Source Software (OSS) brings a wide range of well-known technical benefits like flexibility and dynamicity of solutions (Ardagna et al., 2009), trustworthiness and quality improvement (Lindman et al., 2009), short time-to-market software delivery, lower development and maintenance costs (Goldman and Gabriel, 2005). Furthermore, from organizational perspective, there are other kind of benefits, related for instance, with business performance improvements (e.g. working practices (Almeida and Cruz, 2012), job roles (Alexy et al., 2013), ownership cost (Ardagna et al., 2009)), value creation and value capture.

To achieve and sustain its benefits, all OSS adoption initiatives demand the fulfillment of specific requirements, mainly in terms of available support, resources, capabilities and skills. Thus, before initiating any incorporation of OSS it is crucial to know if an adequate level of business readiness is reached. As far as we know, there do not exist structured approaches to assess organizational readiness in the adoption of OSS, at least embracing both external and internal ecosystems. This weakness not only avoid organizations from reaching the innovative benefits of OSS, but OSS adoption projects do not materialize or do not reach their objectives. In this context, we propose an assessment model to help organizations to identify its current readiness to face an OSS project. The develop of this model is guided by three research questions (RQ):

RQ1 – Which are the main organizational characteristics that can be considered as critical success factor to support a successfully OSS adoption?

RQ2 – How is it possible to organize these characteristics into a generic assessment model?

RQ3 – How is it possible to suggest a way in which OSS should be adopted, based on the assessment model results?

In response to this, we propose the Organizational Readiness Assessment Model for OSS Adoption to estimate the preparation level of an organization to take ad-vantage of OSS, and to suggest the way in which OSS should be adopted. This model was

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applied on CEDIA, a non-profit entity in academic sector, whose members are universities, community colleges and high schools. CEDIA acts as technology integrator and provide a portfolio of over 65 services and programs intended to improve quality of education and research.

The following sections are organized as follows: Section 2 presents the related work; Section 3 describes the model; Section 4 shows the assessment mechanism; Section 5 contains the results of application case; finally, conclusions and work in progress are presented.

# 2 BACKGROUND AND RELATED WORK

This section briefly describes the main concepts applied, and previous work in relation to our proposal.

OSS refers to software that can be freely used, modified and redistributed. The principles that drive OSS (co-creation, openness, innovation, voluntary association, self-organization), create a new paradigm able to change not only the software development but the social and economic value creation. From this point of view, the OSS adoption should be managed as a strategic business decision.

The way in which OSS is adopted by an organization, is called *adoption strategy*. (López et al., 2015) analysing empirical evidence, identifies and model six ways of OSS adoption. Each of them presents a particular set of characteristics which depends in last instance, on how strong the interaction with OSS Developer Community (OSS-DC) is, and which business goals the adopter organizations hope to achieves. These strategies are described below.

- **Release:** Organization releases personalized software as OSS but does not care whether an OSS-DC takes it up or forms around it. No OSS-DC is involved. The organization does not care OSS evolution for maintenance
- **Acquisition:** Organization use existing OSS code without contributing to its OSS project/community. The involvement with the community is minimum after obtains the software and its documentation. The organization does not care OSS evolution for maintenance.
- **Integration:** It involves the active participation of an organization in an OSS community (to share and co-create OSS) but not necessarily leading or influencing it.

- **Fork:** Organization creates its own independent version of the software that is available from an existing OSS project or community. The OSS-DC is forked too. Organization continues the development of OSS component (generally critical ones) and OSS-DC evolves for its own account, to achieve specific requirements.
- **Takeover:** Organization attracts an existent OSS-DC to support its business activity. The creation of its own OSS-DC pursues to 'take the control' of critical software development.
- **Initiative:** Organization initiates an OSS project and creates its own OSS-DC around it, in order to 'take the control' of critical software development.

Regarding technical issues, there is good set of well-known contributions to OSS adoption in the field of information and communication technologies. This research work deals with the business dimensions of OSS and Open Innovation (OI). We conduct our proposal through OI perspective, due to the fact that OSS is perhaps, the most iconic form of OI implementation. In this sense, the work of (Lopes et al., 2017) describes the relationship among knowledge management, sustainable innovations, and organizational sustainability. (Rogo et al., 2014) propose a methodology to assess the performance of OI practices and improves the allocation of intellectual capital resources into value creation process and high-lights the importance of co-evolution between the organization and its customers, competitors and suppliers; here, Intellectual Capital refers to skills and competences of staff, capabilities and knowledge supported by organizational structure; and environmental relationships with external stakeholders. (Secundo, 2020) also emphasizes the role of external stakeholders and its contribution in sharing and transferring knowledge, across technology-intensive organization boundaries with OI. The cause and effects of agglomeration, networks, and trust on OI culture, are integrated in a model proposed by (Nestle et al., 2019), where the need to extend the research on networks and ecosystems is indicated.

In relation with OI assessment, based on a survey among 223 Asian service firms, the work of (Cheng, and Huizingh, 2014) proposes a comprehensive measurement scale for OI that include a wide range of activities, to indicate to what extent a firm has implemented OI activities. This research work deals with innovation performance and consider three points of view: entrepreneurial, market, and resource.

This approach does not consider issues like organizational culture, innovation stage, and lawful knowledge.

Although there is a great variety of research work that describes the relationship among some organizational resources, capacities and skills, there are no a model focused on evaluate the organization as a whole, considering generic areas involved in an OSS adoption project. Hence, we design a model that supports the organizational assessment and suggest the way in which OSS should be adopted.

# 3 CONSTRUCTIVE PROCESS

To take advantage of business benefits derived from OSS, it is indispensable to fulfill a set of specific requirements of OSS adoption strategies, and consequently, it is essential that the organization knows how ready it is to fulfill these requirements.

The internal structure of the organization keeps a close relationship with the organizational performance, facilitating or hindering the way in which the individuals manage the complexity and uncertainty derived from the activity with multiple internal and external actors. In this context, the OSS adoption implies establishing a non-trivial relationship with multiple external stakeholders. The specific association with one of them, the OSS Developer Community, has particular complexity (because has many connections) and uncertainty (because the organization cannot exercise control nor demand commitment, although this stakeholder provides an important OSS component and/or its support service).

For this reason, we propose the *Organizational Readiness Assessment Model*, a support artifact which final objective is to validate the organization's readiness to manage complex relationships and uncertainties derived from the OSS adoption in an organization that works according to open innovation paradigm. It's important to highlight that because the OSS adoption involves both technical and business aspects, a global validation is required.

The constructive process that we use to develop the model, is summarized in Fig. 1. The iterative approach guides the application of four stages, which are described below.

- **Stage 1 – Identification.** The first stage of the constructive process consist on the review of works in three main areas interrelated with organizational OSS adoption: open innovation (wide scope), IT management (medium scope), and OSS adoption itself (short scope).

(Chesbrough, 2006), (Ven and Verelst, 2009), (Spinellis and Giannikas, 2012), (Hogan and Coote, 2014), (Cohen, and Levinthal, 1990), (Branscomb and Auerswald, 2001), (López et al., 2015), (RISCOSS, 2014) constitute the core of support documentation from where we identified a set of organizational issues for the assessment.

- **Stage 2 – Organization and Prioritization.** The issues identified in previous stage were chronologically organized in past (experience in OSS adoption), present (current resources, capabilities, and skills), and future (expectations about OSS projects). Issues in present time were grouped into thematic categories. In order to quantify the organizational compliance of each issue, a numeric scale was assigned, with scores between 0 to 1. Initially, all categories have the same weight in the model.
- **Stage 3 – Decision Support.** In this stage, we stablish a relationship among resources, capabilities and skills available in the organization, and the requirements of OSS adoption strategies identified in (López et al., 2015). This relationship allows us to suggest a specific OSS adoption strategy or strategies, and identify the key issues that should be improved to support OSS adequately.
- **Stage 4 – Feedback.** In this stage, the model can be modified to incorporate enhances suggested by strategic/tactic staff of the assessed organizations, about: new issues, intervals of scoring, weight of categories, and so on.

As a result of applying these four stages, we obtain a model to estimate, in a systematic way, the level of readiness to face an OSS adoption project.

# 4 MODEL DESCRIPTION

The model constructed in previous section contains nine categories, as shown in Fig. 2. In this section, we describe briefly each of them. When the organization has completed the assessment, the next step is to know how to carry out the adoption process. To contribute to identify the most suitable path to adopt OSS, we work with the proposal of (López et al., 2015), which describes six ways in which the organizations usually adopt OSS.
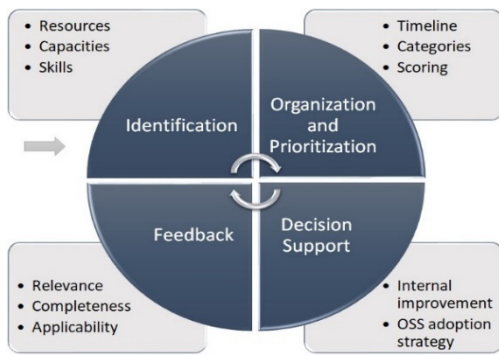
Figure 1: Constructive Process.

## 4.1 Section A: OSS Experience

This section aims to identify the kind of knowledge and learned lessons obtained by the organization from previous OSS works. This experience brings to the organization a valuable support in practical issues of OSS adoption.

**A1 Organization's OSS Experience:** it refers to the main feature of previous organizational experience with OSS, from no existence, to existence of high complex experience.

**A2 Staff's OSS Experience:** it assesses the main previous OSS experience that the staff has had outside the organization, from no existence to existence of high complex experience.

**A3 Organization's Previous Related Knowledge in the Organization:** The work of (Cohen, and Levinthal, 1990) argues that prior related knowledge enables the organization to assimilate and use new outside knowledge, and has a reinforcing effect. This knowledge should be structured. The innovation projects require both commonality knowledge (which improves the communication among staff of diverse areas), and individual knowledge (which maintains the diversity). (Steinmacher et al., 2015) identifies the lack of previous knowledge as an incoming barrier faced by newcomers. Thus, the prior related knowledge in the organization is estimated in the range from inexistence on OSS domain or related fields, to existence of knowledge identified and available.
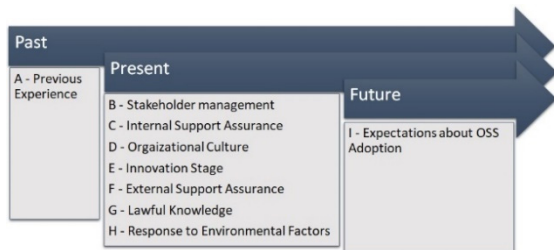


Figure 2: Model Structure.

## 4.2 Section B: Stakeholder Management

It identifies if the organization has a structured and systematic management of stakeholders, which bring support the relationships involved in OSS adoption. The organization should manage a minimum schema that allows it to identify, classify and prioritize the stakeholders according to the importance level that they have.

**B1 Stakeholder Relationship Management:** it refers to the existence of defined process to manage the organizational relationships with its external stakeholders.

**B2 Stakeholder Prioritization Criteria:** it refers to the existence of a defined criteria to assign a prelation order in which the stakeholders are managed and its satisfaction is monitored.

## 4.3 Section C: Internal Support Assurance

This issue evaluates the support level that the organization can bring to OSS adoption, from the perspective of open innovation. This issue has a critical role because identifies the responsibilities and commitments that the organization must met in order to give viability and sustainability to OSS initiative.

**C1 Business-IT Alignment:** This issue asks for the alignment of Information Technologies issues to business, i.e., to what extent the IT operations support the business goals, business strategy and mission.

**C2 Strategic Commitment for OSS:** It is the strategic commitment that can obtain an OSS project, through initiative sponsoring and basic requirements (i.e. budget, resources project management support, business process management support), valued using three possible responses, from the no offering of strategic commitment to OSS, to refer that this commitment is feasible. This resource commitment (financial, material, logistic, etc.), contributes to avoid or reduce delays. (Spinellis and Giannikas, 2012).

**C3 OSS Technical Skills:** they are the technical skills required for OSS adoption (i.e. crowdsourcing, collaborative teams, agile development).

**C4 Technical Support for OSS:** It is the internal technical support available to OSS (it refers to staff effort, hardware and communications resources). (Spinellis and Giannikas, 2012) show that "organizations in fields with a high IT-usage intensity could be more likely to adopt OSS". This issue indicates the availability of support.

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**C5 Learning Capacity (LC):** Known as the "the capacity to develop knowledge" (Hult et al., 2001), or "the organizational potential to use available knowledge within the organization and to continually renew that knowledge" (Prieto and Revilla, 2003), the ultimate impact of Learning Capacity (LC) is to improve the organizational innovation and performance. The present assessment seeks the organization's expert criteria to identify the LC level (high, medium, or low) that can support the learning required by OSS adoption. It is assumed that in every organization has at least individual learning capacity.

**C6 Absorptive Capacity (AC):** The Absorptive Capacity (AC) (proposed by (Cohen, and Levinthal, 1990), and reformulated by (Zahra and George, 2002) is considered as the set of routines and processes by which organizations systematically identify, acquire, assimilate, transform, and exploit knowledge; in turn, this knowledge impact the levels of organizational innovation and performance. According to (Cohen, and Levinthal, 1990), previous to AC, the internal Research and Development (R&D) should be developed to generate Prior Related Knowledge that allows the assimilation of the external knowledge. Part of AC is the facility to adopt technologies, referred by (Spinellis and Giannikas, 2012) as the use of technologies, the obtainment of advantage of its use, and the general adoption experience. In this context, the present assessment seeks the organization's expert criteria to identify the AC level.

**C7 Human Talent:** it refers to the innovation-driven approach (i.e. the existence and application of innovation processes, policies and systems) present or not in hu-man talent management. This variable has three sub-components: a) staff conformation, b) staff operation, and c) innovator's role. The first two are referred to the support that the human talent management offers to the innovation process. The last one is referred to the existence of innovation role(s) clearly defined and focused on monitoring the environment, sourcing knowledge, and communicating the knowledge (to their organization and across their organization) (Cohen, and Levinthal, 1990), (Huang et al., 2017).

**C8 Disseminative Capacity (DC):** As part of the knowledge transfer process, the Disseminative Capacity is referred by (Tang et al, 2010) as "the ability of knowledge holders to efficiently, effectively, and convincingly frame knowledge in a way that other people can understand accurately and put into practice". In the present assessment, DC is valued both internal level (among individuals and groups) and external level (between the organization and its stakeholders).

**C9 Open Innovation Process Management:** OSS developing practices as agile end-user and volunteer driven, have a marked difference with traditional software development processes (Spinellis and Giannikas, 2012) because, among other factors, OSS is a way of open innovation (Chesbrough, 2003), and as such, its adoption requires flexibility not only at software development level but at business level. The business importance of open innovation process management is treated in (Lendel et al., 2015), and organizational issues required by OSS (for instance, process reengineering, leadership role in ecosystems) are identified in (Appleyard and Chesbrough, 2017).

## 4.4 Section D: Organizational Culture

The organizational culture comprehends norms, systems, symbols, language, assumptions, beliefs, habits, collective behaviour patterns, and assumptions. All of them shape and characterize the organization, and are able to facilitate and promote the innovation. In this sense, (Hogan and Coote, 2014) show that values, norms and artifacts steer innovative behaviours, and these in turn impact on organizational performance.

From works of (Hogan and Coote, 2014), (Cohen, and Levinthal, 1990), (Branscomb and Auerswald, 2001), a set of elements from the innovation-oriented organizational culture was selected to be evaluated.

**D1 Valuation of Organizational Performance:** The value that the organization attributes to success, high and innovative performance, challenging goals, motivates staff and improves the innovative solutions and in general terms, helps to develop a proactive behaviour.

**D2 Agreement to Openness and Flexibility:** An organization opened to new ideas and new approaches to solve problems, facilitates the generation of creative solutions, the discovering of new paths to achieve these solutions, and decreases the resistance to changes.

**D3 Organizational Tolerance to Risk:** All innovations have a certain uncertainty level, because their potential impact (at organizational and environmental level) can be positive or not. In this scenario, the "willingness to engage in and encourage behaviours and activities with uncertain outcomes" (Chapman and Hewitt-Dundas, 2017), referred as risk tolerance, is one of the influential factors to undertake an innovation project.

## 4.5 Section E: Open Innovation Level

Thus, guided by the Open Innovation Paradigm (Chesbrough, 2006), (Chesbrough, 2003), the open innovation stage is estimated in general terms, through the following axis: Innovation Process Management, Intellectual Property Management, Technology Management, External Stakeholder Management, Market Knowledge Management, Customer Offering Planning, Value Added Management

## 4.6 Section F: External Support Assurance

This section identifies the source of specialized support level to OSS adoption that the organization can obtain from third parties. This refers to potential support provided by other division, business unit, or area of the own corporation.

## 4.7 Section G: Lawful Knowledge

This appraisement aims to identify the level of organizational knowledge about legal and regulatory issues related to open source. This is integrated by three components: licensing knowledge, IP and Copyright knowledge, and IP policies.

**G1 Licensing Knowledge:** It is the organizational knowledge about OSS licensing, valued using four alternative responses, from no knowledge, to high level of knowledge.

**G2 IP and Copyright Knowledge:** It is the organizational knowledge about Intellectual Property regulations, valued through four alternative responses, from no knowledge, to a high level of knowledge.

**G3 IP Policies:** this component is referred to the existence of protection terms for the organizational knowledge, and has develop of correspondent IP policies. There are three possible responses, from the no existence of protection terms or IP policies, to the existence, diffusion and application of this policies.

## 4.8 Section H: Response to General Environmental Factors

The environment has influence in how the organization operates. There are external factors that can impact on open innovation initiatives (OSS in particular) either promoting them or restricting them. The management of these factors is assessed from the point of view of the value network to which the organization pertains, and from the perspective of the organization.

## 4.9 Section I: Expectations about OSS Adoption

This section is oriented to identify the role that the company has planned for OSS, in relation with the customer offering, the Internal Development Team, and the link with OSS Developer Community. These issues are described below.

**I1 OSS Inclusion in Customer Offering:** The inclusion of an OSS component as part of the customer offering (unlike using it internally) involves issues like customer relationship, image, incomings, and market, among others. The specific role planned for OSS as part of customer offering gives a general idea of the organization's awareness of resources to invest in the OSS adoption.

## 4.10 Suggestion of OSS Adoption Strategy

As we introduce in Background Section, the work of (López et al., 2015) shows six OSS adoption strategies. Due to the main external stakeholder in them is the OSS-DC, they were organized into three groups, according to the interaction level between the organization and the OSS-DC. Hence, we define three interaction levels: Low-none, where organization has a minimal relationship with OSS-DC, or no exist relationship at all (Release, Acquisition, and Integration); Medium, where organization has a limited relationship with OSS-DC, through sending patches, requirement specifications, performance reports, and so on (Fork); and High, where organization has strong and permanent relationship with OSS-DC through co-development (Takeover, and Initiative).

# 5 APPLICATION CASE: CEDIA

## 5.1 General Description

A questionnaire was developed as assessment mechanism, based on the schema presented in Section 4. This questionnaire contains 40 closed polytomic questions derived from issues at level 2, and uses a Likert Scale of 3, 4, 6 or 9 points (where the points for a question are not overlapped). These questions are exhaustive (includes all possible responses) and mutually exclusive (it is not possible the co-existence of two or more responses for each issue). Only one question includes the possibility of an open response: the case of OSS experience, where the interviewed

can respond with a description of its particular OSS adoption way.

CEDIA was selected according to the following criteria: a. To have experience in OSS adoption projects; b. To include OSS as part of customer offering; c. To have (or have had) some relationship with OSS-DC. After selecting the organization, the following criteria were stablished to identify the most suitable executive profile to response the questionnaire: a. To have experience as Technology, Innovation, and Business Management; b. To have decision-making facilities (in terms of resource assignment) over OSS related projects; and c. To have software engineering background (desirable), specifically in requirements management, and system integration, areas. The responses were given by a high executive of CEDIA.

The following subsections describe each issue to be assessed.

As we see in Fig. 3, CEDIA has a high compliance level in most categories, and an average compliance of 84.4%. In the following paragraphs, we present the main findings.

About previous staff experience on OSS adoption. Although the staff reports an experience quantified of 37.91% (considered low level), it does not affect the subsequent performance in OSS projects.

According with the obtained scores, and applying the suggestion schema proposed in Subsection 4.10, we found that CEDIA is ready to carry forward OSS adoption strategies that involves low and med relationships with OSS-DC.

In the case of strategies with high involvement with developer's community, it is important to reinforce the capacities and skills related to environmental interaction (improving the process to manage relationship with OSS-DC, and the criteria to prioritize internal-external requirements). The lack of knowledge and confidence in its environment, may be one of the reasons why CEDIA has a medium level of risk tolerance (Section D – Organizational Culture) and a medium level of development of its value network (Section H – Response to General Environmental Factors).

## 5.2 Threads to Validity

The validation of a proposal using a single case, might introduce bias (either by excluding important elements or by over valuate others) that makes difficult to generalize its conclusions. To reduce this threat, we place special attention on selecting the organization where perform the application case.
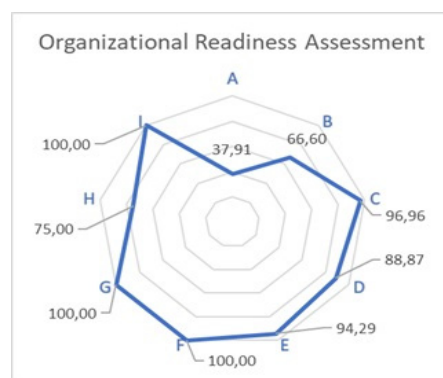


Figure 3: CEDIA Assessment Results.

This organization satisfy the following additional criteria: a) representativeness: has a common cases of OSS adoption b) truthfulness: we have free access to historical and current information about OSS initiatives.

## 6 CONCLUSIONS AND WORK IN PROGRESS

In this paper, we present a model to assess the organizational readiness for Open Source Software, from open innovation business perspective. In response to the research questions (RQ) stablished in Section 1, the following results were obtained. RQ1: A meaningful set of skills, capacities and resources related with OSS adoption in Open Innovation environment were identified. RQ2: we organize the results from RQ1 into 9 categories grouped in 3-time instances (past, present and future) that integrate the structure of the *Organizational Readiness Assessment Model*. RQ3: After our model application, an OSS adoption strategy(ies) can be suggested, mapping the estimated level of organizational readiness, with the business requirements of OSS adoption strategies.

The main benefits of our proposal are: a) establish a solid and systematic criterion to identify organizational issues involved in OSS adoption; b) organize these issues in categories that can facilitate the strategic user assessment; c) suggest a type of OSS adoption strategy, according to organizational readiness; and d) identify aspects that should be improved in organizations, mainly in terms of Business-IT alignment.

Other important benefit of our proposal resides in the fact that it can be used with minor adjustments in any organization, independently of its nature or industry to which pertains. Accordingly, the proposed

method constitutes a decision-making tool that helps adopters to take advantage of OSS benefits.

We continue to specific work on two issues: a. to identify the synapsis between organizational readiness and its correspondent OSS adoption strategies, in order to disaggregate these connections to goal, risk, and cost level; and b. to apply the model in other representative organizations, once the model structured has been improved using current feedback.

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