Operationalizing sustainable transparency in software ecosystems portals

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Abstract. *Transparency is a key element in software ecosystems (SECO) and promotes trust, collaboration, and accountability. However, current transparency measures focus mainly on technical aspects, such as code openness or Application Programming Interface (API) accessibility, while focusing less on social, organizational, and economic characteristics. This paper introduces a Key Performance Indicator (KPI) framework to operationalize sustainable transparency in SECO portals. Our mixed method begins with a longitudinal review of previous research and proceeds to define KPI aligned with measurable goals. Expert evaluations will be conducted, through structured interviews, to assess the feasibility of the proposed KPI. In addition, a feasibility study in a representative SECO setting will explore how this framework can strengthen existing transparency efforts and inform continuous improvements in ecosystem management. The goal of this research is to contribute to the field of information systems by providing actionable data-driven insights that can enable SECO management teams to monitor and improve transparency across multiple characteristics and thus support the long-term sustainability of digital platforms.*

1. Introduction

Transparency is a key concern in information systems (IS), particularly when looking at software ecosystems (SECO). This paper defines transparency as the ability to access, use, understand, and verify the quality and accuracy of information [Zacarias et al. 2023]. Moreover, a SECO refers to a community of software developers, platform providers, and third-party contributors centered on a technology platform [Jansen et al. 2009]. Examples include open-source platforms (e.g., GitHub), mobile app stores (e.g., Google Play), and public service portals (e.g., the European Data portal or the Brazilian Gov.br services).

SECO portals play an important role in enabling interaction with a common technological platform by offering developers access to tools, documentation, and platform requirements to build application. However, current transparency measures often focus on technical openness, such as open source accessibility and API documentation [Zacarias et al. 2024]. This approach overlooks the social, organizational, and economic characteristics that influence trust, governance, and long-term sustainability of the ecosystem [Bosch 2010]. Studies have shown that increased disclosure alone does not necessarily lead to genuine transparency [Schnackenberg and Tomlinson 2016]. Without structured ways to assess transparency across these characteristics, SECO management teams

lack insight into potential gaps, making it difficult to track improvements or address developer concerns effectively [Hou and Jansen 2022].

This paper introduces a Key Performance Indicator (KPI) framework to operationalize sustainable transparency in SECO portals. The goal is to provide measurable insight that helps SECO management teams monitor transparency characteristics and support long-term sustainability. The framework builds on conditioning factors for transparency identified in the literature [Zacarias et al. 2024] and incorporates hotspot analysis, a method that detects areas within SECO portals where users consistently experience difficulties, such as delays in finding information or navigation issues [Lima et al. 2022]. By defining transparency as a measurable and continuous process, this study examines how KPI could help SECO platform management teams track transparency characteristics, identify weak spots, and consider actions based on the SECO portal usage data.

To investigate this approach, the study follows a longitudinal study [Tella et al. 2024] of previous work investigating the conditioning factors for transparency in SECO, focusing on how transparency characteristics evolve over time [Zacarias et al. 2024]. Based on measurable goals, KPI are then defined, followed by a feasibility study in a selected SECO environment to explore the practicality of integrating transparency tracking into existing decision-making processes.

By measuring transparency, this research aims to give IS frameworks practical and measurable methods to evaluate transparency on SECO portals and ultimately contribute to the field of IS by responding to a grand research challenges in IS in Brazil [Nunes et al. 2017], specifically by providing actionable insights that address organizational aspects of technological platform design, such as governance and structure, and the social dimension, such as user participation and trust. The following sections discuss the research method, preliminary results and conclude with final remarks and next steps.

2. Research method

This study proposes a framework for measuring sustainable transparency in SECO portals. The main research question is: **How can sustainable transparency in software ecosystem portals be operationalized through KPI?** To explore this question, the study is guided by three subquestions: (1) What constitutes sustainable transparency in software ecosystem portals? (2) Which KPI can be defined and used to measure sustainable transparency? (3) How can these KPI be evaluated and implemented in SECO portals? Our research method consists of three phases: a longitudinal study, KPI development and structuring, and a feasibility study that builds on previous work and addresses practical challenges faced by SECO portal management teams.

2.1. Phase 1: Longitudinal study

Firstly, a longitudinal study is conducted based on the transparency conditioning factors identified by Zacarias et al. (2024). In this phase, we update the original baseline by reviewing recent publications (2023-2025) in the same databases (Scopus, ScienceDirect, ACM Digital Library, Engineering Village, IEEE Xplore) to see how the characteristics of technical, social, organizational, and economic transparency have evolved.

The longitudinal study employs a seven-stage filtering process that progresses from initial search and duplicate removal, followed by hierarchical screening (ti-

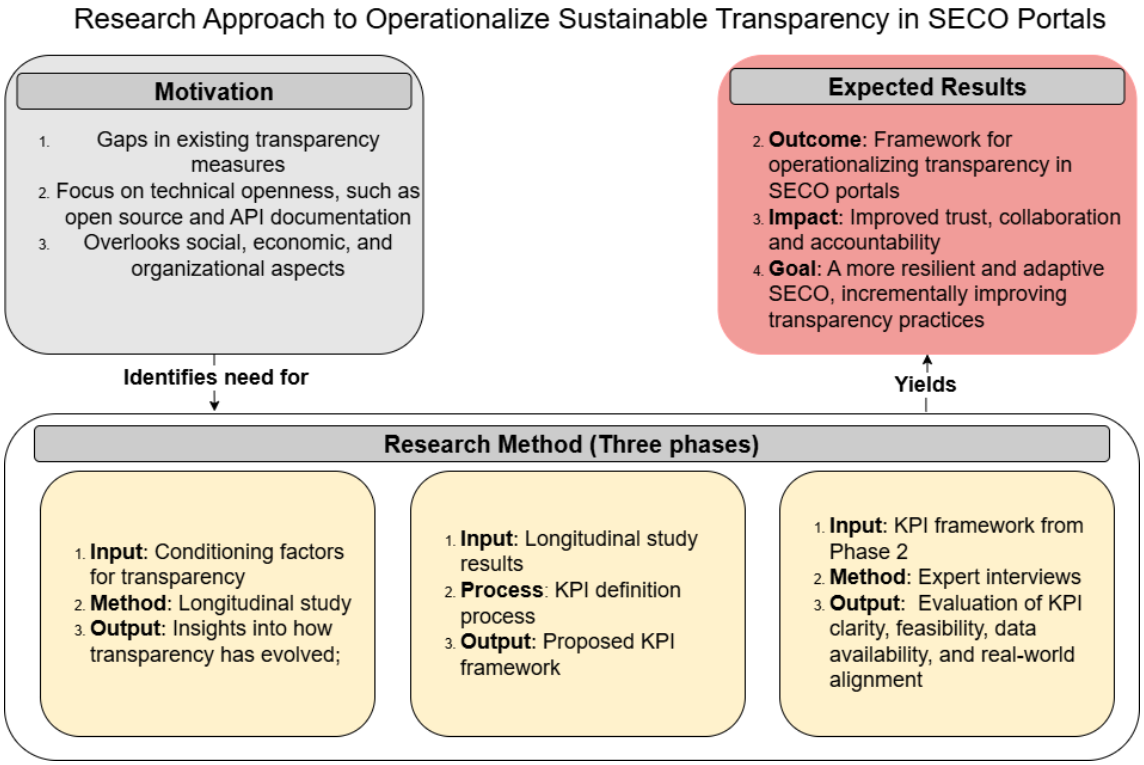

Figure 1. Overview of the proposed approach

tle/abstract/keywords → introduction/conclusion → full text), snowballing, and final data extraction. Inclusion criteria focused on studies addressing transparency or openness in SECO and proposing relevant solutions such as models, methods, or frameworks. The exclusion criteria included studies that were duplicates, not peer reviewed, not primary studies, had less than four pages, no access to full text, or did not meet the inclusion criteria. These criteria were adapted from [Zacarias et al. 2024]. By analyzing how conditioning factors have changed over time, we establish a foundation for defining actionable KPI that reflect current transparency priorities but also allow us to compare emerging trends with previously documented challenges and identify recurring gaps.

2.2. Phase 2: KPI development and structure

Based on insights from the longitudinal study, we use existing frameworks [Parmenter 2015, Banijamali et al. 2024] to define KPI that connect transparency goals to measurable outcomes. This involves linking a goal (e.g., 'improve clarity in decision making') with one or more critical success factors (e.g., 'timely and public dissemination of governance updates'), a relevant metric (e.g., 'percentage of major decisions documented within X days'), a clear performance target, and a corresponding corrective action.

To ensure that KPI accurately reflect user challenges within the SECO portal, a hotspot analysis tracking navigation patterns is included. This analysis tracks factors such as the time users spend on key documentation pages or the frequency of developer searches, identifying areas where stakeholders are experiencing problems. If the data show that developers consistently exceed a predefined search time for certain information, managers can adjust KPI or take corrective action, such as refining the documentation

structure. A data tracking tool will be used to collect and analyze these interaction data directly from the SECO portal [Lima et al. 2022]. Additionally, we recognize that more complex characteristics, such as accessibility, may require multiple subgoals, and we consider transparency a nonfunctional requirement that should be aligned with ISO standards [International Organization for Standardization 2011] when applicable. The ISO standards provide guidelines for ensuring software quality and consistency, which supports transparency by offering direction to guarantee system performance.

2.3. Phase 3: Feasibility study

Finally, a feasibility study will be conducted to assess the practical application of the proposed KPI framework. Instead of complete validation, the study evaluates the feasibility and relevance of the framework in an SECO setting. The main aspects are described next:

- **Expert Evaluation:** Interviews with SECO managers and developers gather feedback on the clarity, usability, and feasibility of each KPI. This will help determine whether the KPI capture the necessary transparency characteristics;
- **Data Collection:** SECO portal usage data, such as documentation access logs and developer feedback, will be analyzed to compare perceived transparency issues with KPI metrics. This includes applying analysis to determine whether the KPI reflect true interaction patterns;
- **Evaluation Criteria:** The feasibility study will focus on whether KPI are quantifiable, targeted, and feasible; whether the necessary data are available; and if the proposed corrective actions are clear and feasible.

By combining insights from the longitudinal study, the KPI framework, and a feasibility study, our mixed method will answer the question of how to operationalize sustainable transparency in SECO portals.

3. Preliminary results

This section presents the initial findings of the longitudinal study and demonstrates how we plan to operationalize one of the conditioning factors for transparency through a KPI template. Although data collection and filtering are still in progress, these preliminary insights help us realize our approach to measuring transparency in SECO.

3.1. Literature searches

As a first result of our longitudinal study, with the process described in phase 1, we found a variety of relevant publications. This is important because the use of the same search terms and databases as in the baseline study ensures the consistency and comprehensive coverage of the SECO research domain. The initial 816 results are as follows:

Table 1. Retrieved studies per database

Database	Number of studies
Scopus	168
ScienceDirect	62
ACM Digital Library	305
Engineering Village	217
IEEE Xplore	64

After removing duplicates, 658 unique studies remained. So far, 54 studies have passed the first filtering round based on title, abstract, and keywords. A second filtering round, based on the introduction and conclusion, reduced this set to 28. Full-text analysis is currently ongoing.

These initial results show that most studies focus mainly on technical openness, such as open source code or API documentation. In contrast, the social, organizational, and economic aspects of transparency are less discussed. This shows the need to approach transparency in SECO portals as a broader multidimensional concept.

3.2. Conditioning factors for transparency in SECO portals

Building on previous research [Zacarias et al. 2024], we identify eight key conditioning factors that play an important role in the promotion of transparency within SECO portals. These factors were selected based on their recurrence in the literature and their relevance to the design of the SECO portal. Table 2 summarizes these factors and their main characteristics.

Table 2. Conditioning factors in SECO

ID	Conditioning factors	Main Characteristic
1	The existence of **communication channels** between actors and the keystone	Stakeholders interaction
2	Information about the platform made available in an **accessible** way	Information accessibility
3	The actors' **understanding** of SECO information	Information comprehensibility
4	The **quality of platform information** provided by a keystone	Information quality
5	The **usability** of interfaces with platform documentation	User experience
6	The **auditability** of platform processes and information	Traceability
7	**Visualization of the evolution of projects** in the SECO	Project monitoring
8	**Reliability of information** provided by a keystone	Information trustworthiness

3.3. KPI Template: Example applied to a conditioning factor

To show how conditioning factors can be translated into operational indicators, we present a KPI example based on CF1 (communication channels). This KPI tracks the percentage of community questions that receive a verified response within a defined time frame (Y days). Supporting metrics include the total number of incoming questions, the average response time by question type, and the amount of verified responses marked as verified. A target threshold (for example, X% responses within Y days) is defined and if unmet for two periods, corrective action is initiated, such as increasing moderator support or improving FAQ quality (see Figure 2).

<table>
<tr><th colspan="6">KPI Building Blocks for Communication Channels in SECO</th></tr>
<tr><th>Goal</th><th>Critical Success Factor (CSF)</th><th colspan="2">Key Performance Indicator (KPI)</th><th>Metric(s)</th><th>Measure(s)</th></tr>
<tr><td rowspan="3">Ensure seamless interaction between developers and the keystone, fostering engagement and timely information exchange.</td><td rowspan="3">Maintain multiple, active, and user-friendly communication channels (e.g., forums, issue trackers, Q&A sections).</td><td colspan="2">Percentage of support queries in community forums that receive a verified response within Y days.</td><td rowspan="3">- Number of support queries posted per period (e.g., month/quarter)

- Percentage of queries receiving a verified response within Y days</td><td rowspan="3">- % of support queries with at least one verified response within Y days.

- Average response time (in hours or days) per query type.</td></tr>
<tr><th>Target</th><th>Action(s)</th></tr>
<tr><td>≥ X% of queries (threshold defined by SECO manager) should receive a verified response within Y days</td><td>If the target is unmet for two consecutive periods (e.g., quarters):

1. Increase moderator engagement or automated assistance (e.g., AI-driven FAQs).

2. Improve documentation to reduce repetitive queries.</td></tr>
</table>

Figure 2. Example of KPI template applied to a conditioning factor

Although this example only illustrates CF1, we acknowledge that measuring all eight conditioning factors involves different methodological challenges. Following KPI development approaches in platform monitoring [Banijamali et al. 2024] and guided by design principles [Fatima et al. 2024], our approach combines platform analyses for technical and behavior dimensions (for example, accessibility, documentation quality) with survey-based or expert evaluations for more qualitative aspects (for example, trustworthiness, comprehensibility). Thresholds are either derived from benchmark studies or calibrated during the feasibility phase based on usage patterns and contextual constraints within the SECO.

To capture interdependencies between transparency dimensions, the framework includes cross-referencing between selected KPI. For example, improvements in communication (CF1) may correlate with better project evolution visualization (CF7), as developers become more effective in articulating and sharing changes. This structure helps SECO management teams to approach transparency as a systemic quality composed of interdependent indicators, rather than a set of isolated metrics. These interdependencies are important for supporting the long-term sustainability of the SECO, as they ensure that transparency efforts remain aligned with evolving stakeholders needs.

4. Final remarks and next steps

This study introduces an initial framework to operationalize sustainable transparency in SECO portals, leveraging potential actionable KPI informed by conditioning factors identified in the literature. The ongoing longitudinal study aims to update and expand our understanding of transparency in SECO, particularly highlighting gaps in governance clarity, information accessibility, economic transparency, and developer engagement.

Currently, our findings are preliminary and based on an initial assessment of available literature. The complete update of the longitudinal study is still in progress, which will inform further refinement of the KPI framework. The next steps include finalizing the longitudinal study, conducting expert interviews, and performing a feasibility study. These activities are important to evaluate the effectiveness of the framework in real-world settings and to ensure that it is in line with the actual needs of SECO managers and developers.

By creating a clear data-driven way to measure and improve transparency, this research aims to help SECO management teams make better decisions by building more trust, collaboration, and accountability on digital platforms. This study also contributes to the field of information systems by addressing a grand research challenge in IS in Brazil [Nunes et al. 2017], connecting with practice, and giving SECO managers practical tools to solve transparency problems. This not only helps researchers understand transparency better, but also gives managers real ways to make SECO more sustainable and transparent by embedding transparency into continuous monitoring and platform adaption processes.

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