Boundary Resources – A Review

Research Paper

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Abstract. Boundary resources mediate access to platform capabilities, enabling complementors to create applications while allowing platform owners to govern interactions. Despite their importance, boundary resources remain underexplored in four key areas: (1) the financial impact of opening platforms, (2) the dominance of consumer-based platform and boundary resource research, (3) the lack of clarity in platform definitions from a boundary resource perspective, (4) the limited conceptualisation of complementors, particularly in enterprise and artificial intelligence (AI) driven contexts. We propose a research agenda that advances the theoretical understanding of boundary resources in monetisation, platform evolution and complementor evolution while offering practical insights for platform managers and complementors.

Keywords: Boundary Resource, Platform, Complementor, Research Agenda, Literature Review

1 Introduction

Digital platforms have revolutionized the way organizations create value, largely through the pivotal role of boundary resources. These boundary resources, such as Application Programming Interfaces (APIs), Software Development Kits (SDKs), documentation, or social events, such as meetups or hackathons, serve as connectors and governance tools for the interactions between digital platforms and complementors. They enable the extension of a platform's core functionalities, facilitating a relationship that allows platform owners to enhance their ecosystems and attract customers, while complementors reap the benefits of the platform's network effects. The resulting ecosystem emerges through the interplay of the platform, its complements, and the boundary resources that structure and mediate their interaction. (Tiwana *et al.*, 2010; de Reuver *et al.*, 2018; Gawer, 2021).

Despite their importance, research on boundary resources remains fragmented. Studies examine their role in platform openness (Ghazawneh & Henfridsson, 2013; de Reuver *et al.*, 2018; Hein *et al.*, 2020; Gawer, 2021) or as control mechanism (Ghazawneh & Henfridsson, 2010; Bender, 2020; Karhu *et al.*, 2020; Gawer, 2021).

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Openness entails a strategic trade-off. As platforms evolve from prioritizing value creation to securing their position, platform owners may restrict access, deprecate boundary resources, or internalize functionalities initially developed by complementors. Such measures enhance platform control but risk undermining complementor business models and affecting the broader ecosystem dynamics (Ghazawneh & Henfridsson, 2013; Broekhuizen *et al.*, 2021; Kude & Huber, 2025).

For example, following the Cambridge Analytica scandal, Facebook implemented more granular user controls over personal data sharing and imposed significant restrictions on its application programming interfaces. The incident revealed that a third-party complement – a quiz-based application installed by approximately 270,000 users – had gained access not only to the personal data of those users but also to that of their Facebook friends, ultimately affecting millions of individuals without their explicit consent (van der Vlist *et al.*, 2022; Huang & Krafft, 2024). In a similar vein, platform owners may privilege their own complements, as demonstrated by Google's approach to its Android mobile operating system, where it pre-installed and favoured its own browser, search engine, and digital marketplace – placing third-party complementors at a disadvantage (Choi *et al.*, 2025). Such practices can create substantial tension within the ecosystem, leaving complementors dependent on opaque and shifting platform governance decisions (Kude & Huber, 2025).

At the core of this tension lie boundary resources, which simultaneously enable third-party innovation and serve as mechanisms of platform governance (Weiss *et al.*, 2022). Yet, their specific role in mediating this trade-off remains insufficiently understood. How can platform owners and complementors strategically employ boundary resources to pursue their respective objectives?

Given, these inconclusive and fragmented findings across the literature, in this paper we ask:

- **RQ1:** What is the state of research on the use of boundary resources in digital ecosystems?

We address this research question through a structured literature review. This review identifies four fundamental problems in boundary resource research that require further investigation

First, while platform openness is widely discussed, little research explains the strategic and financial motivations behind it. Studies frequently emphasise that platforms open to enable co-creation (Eaton *et al.*, 2015; Islind *et al.*, 2016; Schreieck & Wiesche, 2017; Hein, Weking, *et al.*, 2019; Schreieck *et al.*, 2021), yet it remains unclear why co-creation is valuable beyond ecosystem growth. How do firms balance risks and benefits of opening their platforms, and what role do boundary resources play in shaping these incentives?

Second, a substantial portion of boundary resource research focuses on B2C platforms (Ghazawneh & Henfridsson, 2010, 2013; Eaton *et al.*, 2015; Qiu *et al.*, 2017; Cennamo *et al.*, 2018; Karhu *et al.*, 2018; Sobota *et al.*, 2022), raising concerns about the generalizability of the findings. Business-to-business (B2B) platforms operate under different conditions where network effects, ecosystem governance, and boundary resource development may not follow the same path (Belleflamme & Peitz, 2021). This

leads to an open question: Can B2C platform findings on boundary resources be applied to B2B ecosystems, or do they exhibit different dynamics or characteristics in B2B settings?

Third, what qualifies as a platform? Some definitions suggest that any extensible software system can be treated as such (Tiwana *et al.*, 2010; Rudmark & Ghazawneh, 2011; Hein *et al.*, 2020). This definition would mean that modular software architectures, such as microservices, are considered platforms as well. By definition, any software providing technical boundary resources is extensible. The lack of clear distinction between platforms and standalone software components complicates boundary resource research.

Fourth and finally, in B2C contexts, complementors are often independent developers or firms that create applications for a platform. However, in B2B settings, complementors are other enterprises that integrate services rather than developing standalone apps (Foerderer *et al.*, 2018). Existing research implicitly assumes that boundary resources are exclusively used by human actors (Benlian *et al.*, 2015; Kim *et al.*, 2016; Parker *et al.*, 2017). However, with the advance of automated solutions, such as generative artificial intelligence (GenAI), this assumption may no longer hold. Must boundary resources be designed differently to accommodate both human and machine-driven complementors?

Based on these four problems, we address our second research question:

- **RQ2:** How needs future research to address these four open research deficits?

This paper presents a systematic literature review on the use of boundary resources in digital platform ecosystems, analysing 89 publications. The findings are structured around three overarching topics from the literature: (1) governance and application of boundary resources, (2) complementor engagement and strategic positioning, and (3) monetisation and evolution of boundary resources. These themes are mapped onto a research agenda that addresses the mentioned problems in the literature: (1) the strategic motivation behind platform openness, (2) the limited focus on B2B ecosystems, (3) the lack of clear platform definition from a boundary resource perspective, and (4) the evolving nature of complementors. This research agenda aims to advance theoretical understanding and guide future studies in boundary resource research.

2 Methodology

We conducted a scoping literature review based on the framework proposed by Arksey and O'Malley (2005) to systematically explore and map the existing research on boundary resources. This approach was used to understand the scope, size, and direction of the literature in this area (Paré *et al.*, 2015; Schryen *et al.*, 2021), as no comprehensive literature review on boundary resources had been carried out to date. The purpose of this review was not only to provide an overview of the current state of research but also to identify key themes, gaps, and conceptual problems, thereby establishing a foundation for future investigations and setting a forward-looking research agenda.

After formulating an initial draft of our research questions, we began with an exploratory phase. Starting from the terms "external developer" and "platform", we employed an unstructured approach to investigate the interactions between them. As our inquiry focus sharpened, we identified and extracted further key terms such as "Boundary Resources", "Complementor", "Digital Platforms" and "Digital Ecosystems" along with their respective synonyms, such as "Software Development Kit", "External Developer", "Two-Sided Network", and "Innovation Platform". The authors judged that these terms were frequently used to describe the dynamic between external developers and platforms. After that we reformulated our first research question to set boundary resources and digital ecosystems at its centre.

The inclusion criteria for this review were confined to peer-reviewed contributions from journals recognized in the Senior Scholars' List of Premier Journals and further A and B journals listed in the German JOURQUAL 4 ranking to extend the range of possible high-quality hits. To broaden the reach further and incorporate the latest insights into the literature review, proceedings from the International Conference on Information Systems, the European Conference on Information Systems, and Wirtschaftsinformatik, were included. Exclusions encompassed non-peer-reviewed sources and working papers, as well as content not published in English.

To capture relevant literature, we crafted a comprehensive search string using boolean operators. The search string was performed on three main databases to guarantee catching all relevant publications[1]: Web of Science, EBSCOhost, and the included proceedings outlets of the AISeL. Since AISeL does not allow content filtering through Boolean search, all proceedings were downloaded as BibLATEX text files to be filtered using a self-written JavaScript process, which searched for hits in the title and abstracts.

Guided by the PRISMA 2020 approach (Page *et al.*, 2021),we filtered search outcomes against our defined criteria. The subsequent manual screening focused on titles and abstracts, leading to a full-text review and eligibility assessment. Publications were excluded if they lacked a concentrated emphasis on boundary resources, did not focus on complementors creating complements for a platform, or if they discussed platforms and complements not specific to software artifacts.

From our initial search, we identified 46 relevant articles. A backward search led to additional discoveries that, if deemed pertinent despite being published in journals beyond our initial scope, were incorporated into our forward-search criteria. In total, this systematic approach yielded 89 articles and conference papers that formed the basis of our review. The selection process, including the PRISMA flow diagram, is summarized in Figure 1 for reference.

[1] Search terms, their synonyms and the Boolean strings for EBSCOhost and Web of Science can be accessed here https://drive.proton.me/urls/D27E74G3AC#8uVNCnNf8X0U

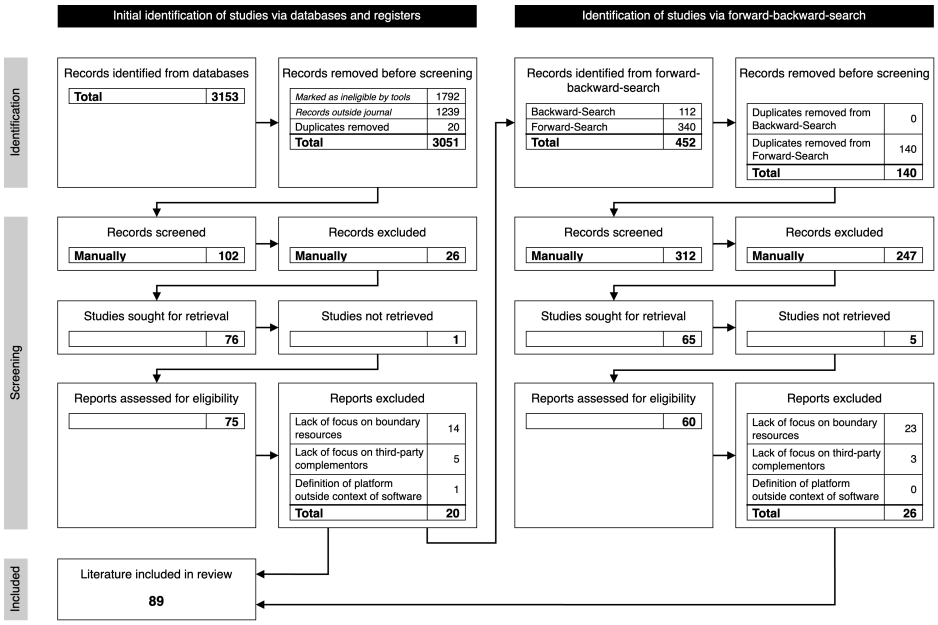

Figure 1. PRISMA 2020 Flow of the literature identification process

We followed the methodological approach outlined by Webster and Watson (2002), focusing on extracting and distilling high-level concepts from the literature by identifying recurring themes. This process involved an exhaustive review of the full texts, during which we extracted and clustered key themes. These clusters were then further summarised. This led to the identification of three overarching topics that underpin this scoping review:

- Governance and Application of Boundary Resources (83 publications)
- Complementor Engagement and Strategic Positioning (25 publications)
- Monetisation and Evolution of Boundary Resources (37 publications)

3 Findings

Each article was reviewed and relevant excerpts marked and collected for analysis. These excerpts were then organized into thematic clusters, which were further refined and summarized into key topics. A significant number of publications focused on themes such as the creation, classification, and standardization of boundary resources, as well as platform evolution. Notably, the governance of boundary resources emerged as the most discussed topic. This emphasis is unsurprising, given that boundary resources often serve as tangible manifestations of platform governance (Weiss *et al.*, 2023), effectively functioning as governance artifacts in their own right. Less publications focused on the degree of complementors integration, complementor strategies or possible monetisation strategies of boundary resources.

3.1 Governance and Application of Boundary Resources

The definition of the digital platform from the perspective of boundary resources remains unclear and can vary dependent on discipline and platform context. Perspectives from economy distinguish between transaction platforms and innovation platforms (Bonina *et al.*, 2021; Gawer, 2021). In information systems research, platforms are often examined as software artifacts, but even with this perspective, definitions differ between studies. For example, Ghazawneh and Henfridsson (2013) built on Tiwana et al.'s (2010) definition of software platforms as an extensible codebase. Foerderer et al. (2018) dissect them further, describing consumer software platforms as offering "a narrow set of functionality", while defining enterprise software platforms as "complex technological systems". Bianco et al. (2014) define software platforms as centrally organized entities that regulate networked ecosystems. These varying definitions make it challenging to analyse platforms in co-creation research and generalise the findings. However, scholars generally agree that platform openness facilitates collaboration between platform owners and complementors.

While early research on platform ecosystems focused on either the complementor or platform owner perspective (Tiwana *et al.*, 2010), boundary resources have emerged as a distinct unit of analysis, providing new insights into platform mechanisms (de Reuver *et al.*, 2018).

Boundary resources grant complementors access to platform functionalities and enable them to develop applications within the ecosystem (Eaton *et al.*, 2015; Wulfert, 2023).

Beneath the co-creation enabled by boundary resources lies a power asymmetry. Platform owners often leverage boundary resources to enforce control, shaping ecosystem rules and dynamics to their advantage (Ghazawneh & Henfridsson, 2013; Bianco *et al.*, 2014). However, complementors are active agents in the platform ecosystem and can apply strategic manoeuvres to actively switch the asymmetry in their favour (Karhu *et al.*, 2018).

Similar to platforms, the definition of boundary resources remains unclear. Early on, boundary resources were conceptualised as purely technological resources exchanging data and capabilities (Ghazawneh & Henfridsson, 2013). However, this perspective later expanded to include social and knowledge-based elements, which provide not only access to technical resources but also guidance on their effective use (Bianco *et al.*, 2014; Foerderer *et al.*, 2018). Therefore, boundary resources extend beyond APIs and SDKs (Petrik, 2022; Weiss *et al.*, 2023), to include many more, like organisational touch points such as license agreements (Leong *et al.*, 2023), direct communication via phone calls (Engert *et al.*, 2022), or debugging tools (Wulfert, 2023).

Throughout this review, we acknowledge the challenge of defining platforms through the perspective of boundary resources and will address these in our proposed research agenda.

Of the 89 publications reviewed, 83 contributed to this overarching topic, likely due to the strong association between boundary resources and platform governance (Weiss *et al.*, 2022).

3.2 Complementor Engagement and Strategic Positioning

The integration depth of complementors in platform ecosystems influences their onboarding, control, and autonomy, shaping strategic positioning. Bender and Gronau (2017) highlight how platform-owned applications often receive preferred treatment, while external complementors face restricted access due to opaque boundary resources, creating power asymmetries that enable the platform owners to absorb external innovation.

Hein et al. (2019) categorize complementor integration into self-service, abstraction, and strategic approaches. While an efficient utilization of platform resources eases the development of applications, it can also lead to lock-in effects and complicate the development of the same complement for several similar platforms, the so-called multihoming (Bergvall-Kåreborn & Howcroft, 2014; Cennamo *et al.*, 2018; Bender, 2020). Though multihoming can dilute application performance, it provides flexibility and reduces platform dependency (Cennamo *et al.*, 2018).

Some complementors challenge platforms through aggressive tactics, that can ultimately power asymmetries in favor of the complementor (Karhu & Ritala, 2021).

Despite these insights, research lacks a clear complementor typology, making it difficult to generalise their integration strategies. Advancing theory will be crucial for understanding how complementors capture value and sustain competitive positioning within platform ecosystems.

3.3 Monetisation and Evolution of Boundary Resources

The monetisation of boundary resources remains an underexplored topic in platform research. While platforms primarily open to expand value co-creation (Zapadka *et al.*, 2022), monetisation strategies for boundary resources are rarely discussed.

Ghazawneh and Henfridsson (2011) propose a conceptual framework for monetising boundary resources of consumer platforms, distinguishing between proactive monetisation, where platform owners recognise and capitalise on new business opportunities, such as Apples in-app purchase API), and reactive monetisation, where control is tightened in response to external monetisation advancements. Despite its strategic relevance, monetisation remains largely absent from boundary resource research.

Recent research has highlighted the financial benefits associated with boundary resources, showing that their existence can significantly enhance a platform's overall valuation. Schreieck et al. (2024) found that investors react positively to banks that open their platforms for external complement creation, with this effect being particularly pronounced in emerging markets. Similarly, Cusumano et al. (2024) discovered that investors are willing to pay a premium for innovation platforms that facilitate third-party development and complement creation, compared to transaction platforms like traditional marketplaces or social media.

While boundary resources enhance ecosystem offerings, excessive externalisation can devalue proprietary resources and erode competitive advantages (Mohagheghzadeh & Svahn, 2016).

The lack of research on the monetisation of boundary resources is problematic for understanding platform openness. Existing research is focused on consumer-oriented ecosystems, overlooking potentially distinct monetisation mechanisms in enterprise platforms, where boundary resources can serve as direct revenue channels. Furthermore, as boundary resources shape complementor participation, their monetisation may have long-term consequences on ecosystems.

Analysing the three presented topics led us to discover four conceptual challenges and gaps future research should address: (1) the missing financial rationale of platform openness, (2) the dominance of B2C-focused research, (3) the unclear conceptualisation of what qualifies as a platform, and (4) the evolving nature of complementors.

Boundary resources are central to enabling platform openness, which makes it essential to understand the financial motivations and monetisation strategies that underpin their use. At the same time, since much of the existing literature focuses on B2C ecosystems, it remains uncertain whether the discovered boundary resource practices apply to B2B platforms, where integration patterns, control mechanisms, and value capture may differ. The definitional ambiguity of platforms in the boundary resource literature further complicates this picture. Boundary resources are often used as indicators of platform status – raising the question of whether a system becomes a platform simply by offering APIs or SDKs. Finally, most research assumes complementors to be human, overlooking potential cases in which boundary resources are accessed by machine agents such as GenAI systems. For example, the usage of the model context protocol (MCP) allows machine learning models to interact with external systems (Hou *et al.*, 2025). These developments may require a fundamental rethinking of boundary resource design and governance.

Moreover, the rationale for opening a platform (1) cannot be fully understood without considering what kind of platform is being opened (3), for whom (2), and for what type of complementors (4).

The following research agenda covers these problems via three topic blocks.

4 Research Agenda

In this section, we present a research agenda that proposes future research directions that is aligned with the four identified problems in the boundary resource research we presented in the introduction. Utilizing Sandberg and Alvesson's (2011) approaches, such as quasi-problematisation, problematisation and new ideas as alternatives to gap-spotting, we have developed research questions for each problem. These questions are accompanied by proposed study designs to further the understanding and theoretical development of boundary resources.

4.1 The Role of Boundary Resources: Defining Digital Platforms

As already outlined, the definition of platforms in the reviewed boundary resource literature remains ambiguous and inconsistent. The lack of conceptual clarity is a challenge for analysing boundary resources within platform ecosystems.

Boundary resources are substantial components in the opening of digital platforms. Yet, their role in platform definition is not examined. Does a system automatically become a platform because it provides APIs, SDKs, or documentation on how to connect to it? Or must boundary resources follow a strategic rational to facilitate governance, market creation, or specific types of network effects for the system to be classified as a platform?

Integrating insights from the literature on platform openness – such as the openness dimensions proposed by Broekhuizen et al. (2021) – with the boundary resource perspective offers a promising path toward a clearer understanding of how digital platforms evolve and open over time and allow for examining how platform openness is driven through the deployment and governance of boundary resources.

Furthermore, while technical boundary resources, such as APIs and SDKs, are recognised, non-technical boundary resources, such as legal agreements (Leong *et al.*, 2023), or communication (Engert *et al.*, 2022), also play a role in platform adoption. The lack of understanding of how boundary resources evolve, mature, and contribute to platform stability remains a critical gap in the literature.

We therefore propose the following research questions:

- How do boundary resources shape to the definition of digital platforms?
- How do platform owners design boundary resource to establish and maintain platform identity?
- What metrics or frameworks do platform owners use to evaluate boundary resource maturity?

To address the research opportunities, we propose the following research designs:

- Design science research to develop a taxonomy on boundary resources and classify them by types, functions and platform types.
- Grounded theory study to understand existing mechanics of boundary resource maturity.
- Design science research to develop a maturity model of boundary resources in the enterprise context.

4.2 Types of Complementors: How Business Models and Complementor Evolution Impact Co-Creation

While platform owners design boundary resources to govern ecosystems, complementors are not passive actors as they can leverage boundary resources to shape their role within ecosystems (Karhu & Ritala, 2021). However, the literature focuses largely on B2C complementors, leaving B2B strategies and enterprises platform dynamics underexplored.

Furthermore, the literature implicitly assumes that complementors are human third-party developers. So far, few publications put the impact of GenAI on boundary resources at the centre of their studies. Research by Mayer et al. (2025) investigates how complementors on a digital education platform use GenAI as a boundary resource to support content creation. Yet, the findings are limited to the content and do not cover the software component level. Yet, GenAI tools like GitHub Copilot support software developers in code generation since years. However, the impact of such automation on boundary resources and digital platforms on the software complement level did so far not reach research. No investigation focuses how boundary resources, such as APIs, SDKs, or documentation, should evolve to accommodate automated software complement creation. Neither are the governance challenges addressed that such practices introduce.

We therefore propose the following research questions:

- How do complementor strategies differ in consumer vs. enterprise platform ecosystems?
- How should boundary resources be adapted for complementors involving GenAI automation?
- What governance issues arise when automated agents utilise boundary resources?

To address these research opportunities, we propose the following research designs:

- Comparative case study design to analyse complementor strategies across consumer (e.g., Apple iOS, Google Android) and enterprise (e.g., Siemens Xcelerator, Airbus Skywise) platform ecosystems, focusing on boundary resource use.
- Grounded theory study to investigate how software engineers interact with boundary resources and GenAI automation.
- Design science study to develop a governance framework for GenAI-driven complementors, outlining how boundary resources must adapt to accommodate automation.

4.3 The Business of Boundary Resources: Monetisation Strategies and Valuation Effects in Digital Platforms

While existing research on boundary resources examines complementor engagement and governance mechanisms, its financial implications remain largely unexplored. So far, research assumes innovation and expansion motivations when opening platforms. However, few studies investigate how this translates into revenue models or platform valuation impact (Ghazawneh & Henfridsson, 2011). Even though platform strategies were found to impact firm valuation (Cusumano *et al.*, 2024; Schreieck *et al.*, 2024), the effect on boundary resource research remains unclear.

Despite its relevance to practice, platform research has largely ignored monetisation strategies for boundary resources. We propose the following questions for future research:

- How do boundary resources contribute to revenue generation for digital platforms?

- How does the opening of a platform through boundary resources impact firm or platform valuation?
- What monetisation models are most effective for different types of boundary resources?

Future research should not only explore pricing strategies but also examine the financial valuation of firms introducing boundary resources in different ownership structures, such as proprietary or open source. By focusing on these areas, scholars can provide actionable insights that help organizations leverage boundary resources for financial performance.

To address these research opportunities, we propose:

- Case study designs to research monetisation strategies of profitable platform firms that sell their capabilities via boundary resources, such as OpenAI, Twilio, or Salesforce.
- Case study design to examine the impact of platform opening through boundary resources on valuation in the merger and acquisition context, as it provides a very clearly scoped environment.

5 Conclusion

This literature review examines governance and application, complementor engagement, and monetisation and evolution of boundary resources to address four problems: (1) the lack of financial clarity behind platform openness, (2) the dominance of B2C platform ecosystems researched in existing studies, (3) the unclear conceptualisation of platforms, and (4) the evolving nature of complementors.

Our findings highlight that governance and application of boundary resources remain fragmented, with platform owners primarily using them for co-innovation and control, while missing insights on their financial impact. Enterprise ecosystems are underexplored, limiting generalizability of existing findings that largely derive from consumer platforms. The assessed boundary resource literature lacks a clear categorisation for distinguishing platforms from modular software systems, raising questions about the platform definition. Finally, the advent of GenAI and automation is shifting the role of complementors, requiring new governance models that address human-machine collaboration in platform ecosystems.

Future research should advance in these areas by examining monetisation and firm valuation models, developing a clear boundary resource taxonomy, and creating advanced governance frameworks to address both human and machine complementors.

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