Orchestration and Governance in the Extended Reality Ecosystem

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Abstract: This study explores through a multiple case study the dynamics related to a nascent ecosystem by examining interactions between orchestrators and complementors within an evolving technological environment. Based on multiple case studies in the extended reality technology landscape, the research identifies critical challenges related to governance, standardization, and alignment. While incumbent firms provide essential infrastructure, their pursuit of proprietary platforms and closed governance models contributes to market fragmentation and to delays in ecosystem consolidation. Complementors, facing strategic ambiguity and lacking coordination, hesitate to commit to any dominant trajectory. This study contributes to the ecosystem literature by highlighting the role of complementors in early-stage ecosystems and to XR scholarship by highlighting the governance and alignment dynamics shaping the evolving technology.

Keywords: Ecosystem, Orchestration, Digital Technologies

1. Introduction

Extended Reality (XR), a collective term for augmented reality (AR), virtual reality (VR), and mixed reality (MR), is increasingly acknowledged as a transformative suite of technologies capable of reshaping business processes, workforce training, product development, and customer engagement across diverse industries. As Porter and Heppelmann (2017) argued, XR holds the potential to unlock novel value creation opportunities, particularly within enterprise applications. Despite significant investments by incumbent technology giants such as Meta, Apple, and Google, XR adoption remains limited.

The strategic integration of XR technologies challenges traditional linear value creation models, requiring a shift toward multilateral and interdependent configurations. However, the formation of XR ecosystems is hindered by the absence of widely accepted standards, fragmented technological infrastructures, and weak alignment among key stakeholders. In such contexts, the ecosystem perspective offers a powerful conceptual lens for understanding how firms mobilize complementors, coordinate innovation efforts, and orchestrate value co-creation (Adner, 2017; Jacobides et al., 2018). While prior research has extensively examined platform-based ecosystems in mature digital markets, less is known about how ecosystems emerge in nascent, technologically immature domains like XR, particularly when led by incumbent firms (Thomas et al., 2022).

This study contributes to the literatures on business ecosystems and XR by examining, through an exploratory multiple-case study (Eisenhardt, 1989), how ecosystems emerge in early-stage, technologically immature environments. Focusing on the Italian XR context, we explore how orchestration unfolds in the absence of dominant platforms or shared governance structures. Our findings show that when the orchestrator's role is unclear, even well-resourced incumbents, who provide essential infrastructure and visibility, may hinder ecosystem development. Their pursuit of proprietary strategies and platform control creates uncertainty for complementors, making it difficult for them to align with a clear direction. This strategic ambiguity delays commitment, weakens collaboration, and slows ecosystem consolidation. We also find that roles between ecosystem actors, such as content creators and software providers, often overlap, adding further complexity. Despite growing interest in XR technologies, the lack of standardization, interoperable platforms, and coordinated leadership continues to limit adoption and ecosystem growth. By unpacking these dynamics, this study offers new insights into how ecosystems begin to form under uncertainty and fragmented leadership.

The remainder of the paper is organized as follows: Section 2 reviews the literature on XR technologies and business ecosystem. Section 3 outlines the methodological approach. Section 4 presents the empirical findings. Section 5 discusses the theoretical implications and contributions to both academic and managerial domains. Section 6 concludes the study.

2. Literature Review

2.1 XR Technologies

Extended reality (XR) constitutes a significant advancement in digital innovation, offering firms novel mechanisms to reconfigure value creation, customer engagement, and operational processes (Porter & Heppelmann, 2017; Meccawy, 2023). Comprised of augmented reality (AR), virtual reality (VR), and mixed reality (MR), XR technologies represent distinct yet complementary modalities: AR projects digital elements onto the physical environment, VR immerses users in entirely simulated spaces, and MR enables real-time interaction between digital and physical domains. These capabilities present considerable potential for strategic differentiation across a wide range of industries (Meccawy, 2023).

The rapid evolution of XR has drawn substantial investment from incumbent technology leaders such as Meta, Google, and Apple (Zabel & O'Brien, 2024; Sag, 2024). Nonetheless, widespread adoption remains constrained by persistent challenges related to usability, interoperability, and the absence of common standards. Previous work focused on mapping the virtual reality value chain (de Regt et al., 2020), however, given XR multisided architecture, encompassing hardware manufacturers, software developers, content producers, platform providers, and end users (Harbor Research, 2022), it necessitates a systemic perspective that accounts for the complex web of interdependencies among participants. As such, XR serves as a compelling empirical context for investigating the emergence of business ecosystems and the orchestration strategies employed by established firms operating within technologically nascent environments (Jocevski et al., 2020).

2.2 Business Ecosystem

Over the past two decades, the ecosystem perspective has emerged as a dominant analytical framework in management and innovation literature to capture value creation in interdependent and dynamically evolving environments. Defined as "the alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017, p. 42), ecosystems enable the generation of co-created value that no single firm could achieve independently (Lingens & Huber, 2021). This conceptual lens is particularly effective in contexts where traditional, linear models, such as value chains, fail to account for complex interfirm dependencies (Jocevski et al., 2020).

As Cobben et al. (2021) note, the field has seen the emergence of multiple typologies of ecosystems, business, innovation, entrepreneurial, and knowledge; yet lacks consensus on theoretical boundaries, governance modes, and performance goals. Among various typologies, the business ecosystem has received particular attention. In this configuration, a central firm acts as the orchestrator, coordinating a network of complementors via shared platforms, governance structures, and technological standards (Moore, 1993; Jacobides et al., 2018). Business ecosystems are not characterized by linear progression but instead evolve through iterative realignments among diverse and often competing actors (Kapoor & Agarwal, 2017), embodying both cooperative and competitive dynamics.

Despite its growing traction, fundamental questions remain unresolved regarding ecosystem emergence and governance, especially when orchestrated by incumbent firms (Krasyuk et al., 2022; Thomas et al., 2022; Lingens et al., 2021). More recent contributions have shifted attention to the evolutionary mechanisms underpinning ecosystem development, such as the articulation of a shared value proposition, role delineation, and the implementation of adaptive governance models (Nylund et al., 2022).

While prior research has largely focused on the orchestrator's role in shaping ecosystem structure and performance, increasing scholarly attention is being directed toward the understudied position of complementors. Their strategic responses, whether through alignment, resistance, or disengagement, are particularly consequential in early-stage and fragmented ecosystems, where stability and coordination remain elusive (Kapoor & Agarwal, 2017; Ritala et al., 2013). A deeper understanding of complementors' behaviors and constraints is thus essential to advancing theories of ecosystem emergence.

2.3 Literature Gap

Although scholarly interest in ecosystem formation has grown considerably, the mechanisms underlying ecosystem emergence in digitally nascent and technologically fragmented contexts remain underexplored (Thomas et al., 2022; Lingens et al., 2021). Much of the existing literature concentrates on platform ecosystems and the role of dominant orchestrators in coordinating value creation and capture (Jacobides et al., 2018). In

contrast, the strategic behavior of complementors, despite their central role in shaping ecosystem dynamics, has received comparatively limited attention (Kapoor & Agarwal, 2017; Ritala et al., 2013).

Emerging research underscores the significance of evolving actor roles, alignment mechanisms, and coordination processes, particularly in settings where orchestrator authority is ambiguous or contested (Shipilov & Gawer, 2020). However, ecosystem emergence processes led by incumbent firms, especially in early-stage digital domains, remain conceptually and empirically underdeveloped (Thomas et al., 2022; Lingens et al., 2021). Given XR's current state of technological immaturity, coupled with increasing investments from established players, it provides a timely and underutilized empirical context to investigate the question: How do the actors of an ecosystem shape its emergence?

3. Methodology

This research employs an exploratory multiple-case study approach (Eisenhardt, 1989) to examine the emergence of the extended reality ecosystem within the Italian market. The study focuses on nine case organizations, representing three primary categories of ecosystem participants: software providers (SP), content creation firms and end user firms. SPs typically develop XR solutions through software engineering, whereas content creators focus on designing 3D assets and immersive environments, they both contribute to the value architecture of the XR ecosystem. These actors represent the complementors of the business ecosystem, it was decided to analyze the relationships with the other actors. Indeed, in the literature the perspective of the complementors in rarely analyzed. Finally, end user firms relate both to companies operating in the business to business and business to consumer fields adopting extended reality solutions.

Additional actors in the XR landscape, such as original equipment manufacturers (OEMs) that produce hardware and operating systems, providers of XR engines that supply the graphical platforms for development and metaverse platform companies were not directly interviewed. However, consistent insights into their roles and constraints were derived from secondary sources and informal interactions.

The data collection process comprised nine semi-structured interviews, yielding approximately 320 minutes of audio and 195 pages of transcripts, supplemented by over twelve secondary sources, including seven consultancy firm reports and five industry reports. The analysis began with a within-case examination to establish a grounded understanding of each case, followed by cross-case analysis to identify patterns, contrasts, and thematic convergence across the dataset (Eisenhardt, 1989).

To structure the findings, we adopted the Gioia methodology (Gioia et al., 2013), organizing the data into first-order concepts based on informant-centric terms, second-order themes reflecting theoretical constructs, and overarching aggregate dimensions. This layered coding strategy ensured analytical rigor and transparency in the link between empirical evidence and emergent theory. In line with Eisenhardt's (2021) recommendations, case selection was driven by theoretical relevance rather than sample size, prioritizing those organizations capable of illuminating the phenomenon of interest. The complete coding structure is presented in Figure 1.

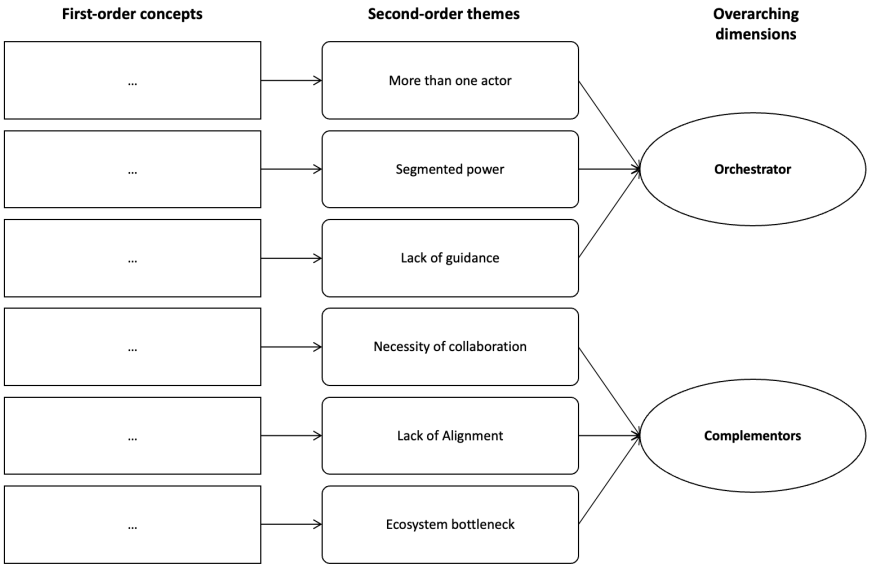

Figure 1: Coding tree structure.

4. Findings

4.1 Absence of Central Leadership

A key pattern that emerged across the cases is the absence of a clearly defined orchestrator within the XR landscape. No single actor currently demonstrates the authority or strategic positioning required to align ecosystem stakeholders, establish common standards, or coordinate investments. Instead, a few dominant incumbent firms, primarily Apple, Meta, and Google, exert influence over core technological layers, such as operating systems and hardware. However, their roles remain fragmented and partial, lacking the integrative function typically associated with ecosystem orchestrators.

These firms retain control over critical device functionalities and software interfaces, which imposes significant constraints on complementors. Respondents consistently highlighted limitations in accessing essential hardware capabilities, such as sensors and camera feeds, as a major barrier to developing complex enterprise solutions.

Some firms interpreted the strategic decisions of incumbents as indirect forms of orchestration. For example, Apple's release of a high-end, enterprise-oriented XR device was seen as a deliberate signal that the ecosystem was not yet mature enough for mainstream adoption. Similarly, Meta's early push into hardware development was perceived as an effort to stimulate community growth and platform lock-in, though its long-term orchestration capacity remains uncertain.

Overall, the absence of a centralized orchestrator contributes to strategic ambiguity and slows ecosystem formation. Complementors face difficulties in aligning their development efforts due to uncertainty over which platform will emerge as dominant. This fragmented orchestration landscape hinders standardization and delays the consolidation of a cohesive XR ecosystem.

4.2 Ecosystem Fragmentation

The Italian XR ecosystem is currently situated in an early and fragmented stage of development. This fragmentation manifests across various layers of the technological stack, including hardware devices, software platforms, and stakeholder roles. One notable empirical insight concerns the blurred boundary between content creators and software providers (SPs), whose functions often overlap in practice. Rather than operating in distinct capacities, these actors frequently engage in both software development and content production, suggesting a convergence of roles that further complicates ecosystem structure.

The interviewee also points to a lack of coherent technological and strategic direction within the ecosystem. This fragmentation appears to have been intensified by the previous wave of enthusiasm around the metaverse, which led to inflated expectations and misaligned strategic investments. The lingering effects of this hype cycle have generated skepticism and diluted the perceived legitimacy of XR as a strategic technology.

Technical incompatibilities across XR hardware and operating systems were identified as a significant barrier to alignment. Developing content for multiple devices often necessitates substantial redevelopment efforts, consuming resources and delaying deployment. Such constraints limit the scalability of solutions and deter long term investment. Many firms reported that client adoption is hindered by uncertainty regarding hardware longevity and platform stability, which undermines trust in XR as a reliable technology.

Furthermore, the tendency of firms to pursue proprietary, siloed development strategies exacerbates fragmentation. Although some actors intentionally avoid integration with third-party platforms to preserve control over margins and product direction, this isolationist stance impedes the emergence of shared standards and collaborative practices. As a result, the XR ecosystem remains disjointed, with limited interoperability and a weak foundation for collective growth.

4.3 Collaborative Dynamics

Across the examined cases, firms consistently underscored the necessity of close collaboration between technology providers and client organizations to realize the strategic potential of extended reality. Given XR's inherent complexity and nascent technological maturity, effective value creation often hinges on co-development efforts. Rather than relying on off-the-shelf solutions, providers must work in tandem with clients to tailor applications that align with specific business processes. This co-creation approach frequently entails the rethinking of existing business models to ensure mutual value realization.

Such projects are resource-intensive and depart significantly from standard software deployments. The success of XR initiatives often depends on the client's ability to dedicate internal teams capable of bridging organizational needs with technical capabilities. Participants across the study agreed that no firm can operate in isolation in this domain; instead, sustained collaboration is a prerequisite for scalable XR adoption.

Despite growing interest in XR applications, a notable disjunction persists between experimental initiatives and large-scale, institutionalized implementation. Many clients still perceive XR as a proof-of-concept technology rather than as a production-ready solution, which delays broader commitment and inhibits ecosystem maturation.

5. Discussion

The extended reality domain offers a revealing context for analyzing ecosystem emergence, as it combines conditions conducive to ecosystem formation, such as interdependence and multilateral collaboration, with many of the structural obstacles typical of nascent technological domains. Echoing established insights from the ecosystem literature (Adner, 2017; Jacobides et al., 2018), the empirical evidence underscores the strategic interdependencies between technology providers and clients, particularly in co-development efforts requiring dedicated internal resources and iterative coordination. These collaborations are further shaped by dependencies on original equipment manufacturers (OEMs), whose hardware and operating system choices critically influence project viability (Lingens & Huber, 2021).

Despite these integrative dynamics, the absence of a dominant orchestrator results in significant technological and strategic disaggregation. Without stable standards or a leading platform, complementors face uncertainty about which trajectory to follow, often deferring adoption. This fragmentation across hardware and software platforms hinders scalable innovation and creates misalignment, a condition widely recognized as essential for ecosystem emergence (Thomas et al., 2022).

The data also point to a lack of ecosystem maturity among end-user firms. Many clients possess limited awareness of XR's capabilities and approach providers seeking exploratory guidance. This blurring of roles between developers and consultants reflects a broader underdevelopment of actor specialization within the ecosystem (Nambisan & Sawhney, 2011).

Notably, unlike traditional platform-led ecosystems or those catalyzed by entrepreneurial actors (Thomas et al., 2022), XR is developing under the influence of powerful incumbent firms, each advancing distinct technological trajectories. This overlapping orchestration complicates alignment, inhibits standardization, and slows ecosystem consolidation.

Considering the findings, the emergence of the XR ecosystem appears contingent upon resolving the **strategic ambiguity** experienced by complementors, who currently lack sufficient signals to commit to specific platforms or ecosystem trajectories (Kapoor & Agarwal, 2017). This ambiguity, exacerbated by overlapping and uncoordinated orchestration attempts from powerful incumbents leads to inertia and inhibits structural alignment (Thomas et al., 2022). To transition from fragmentation to formation, findings show that the XR ecosystem should be supported by **shared orchestration frameworks** that go beyond technological control and incorporate inclusive governance, open standards, and mechanisms for multilateral coordination (Adner, 2017; Jacobides et al., 2018). These dynamics further highlight insights from the digital business ecosystem literature (Hanelt et al., 2021; Senyo et al., 2019), which emphasize that ecosystem emergence in digitally mediated contexts is shaped by technological uncertainty, strategic ambiguity, and fluid inter-organizational roles. However, our findings extend this stream by highlighting how the lack of a clear orchestrator despite the presence of resource rich incumbents can amplify these challenges, especially for complementors navigating early-stage digital convergence.

5.1 Theoretical Contributions

This study makes two primary contributions to the literature on ecosystem emergence and extended reality. First, it extends existing research on orchestration and ecosystem formation (Lingens & Huber, 2021; Thomas et al., 2022) by underlining that ecosystems led by powerful incumbent firms encounter a distinctive form of early-stage complexity. While these actors provide essential infrastructure and market legitimacy, their concurrent pursuit of proprietary strategies and platform leadership introduces strategic ambiguity for complementors. In the absence of standardized governance and clear focal leadership, complementors hesitate to align with a single trajectory, resulting in persistent structural dispersion and hindering ecosystem consolidation. This finding

adds nuance to prevailing models of orchestrated emergence by illustrating how multiple dominant orchestrators, operating without coordination, can obstruct alignment particularly in institutionally fluid and technologically immature domains such as XR.

Second, this study extends research on digital business ecosystems by highlighting how the absence of a clear orchestrator, despite the presence of resource-rich incumbent firms can exacerbate challenges typically associated with early-stage ecosystem emergence. While prior literature has emphasized the role of technological uncertainty, strategic ambiguity, and fluid inter-organizational roles in shaping digitally mediated ecosystems (Hanelt et al., 2021; Senyo et al., 2019), our findings show that overlapping and uncoordinated orchestration attempts by incumbents further amplify these issues. This insight deepens understanding of how misalignment and inertia can persist even in ecosystems supported by powerful actors, particularly when complementors lack guidance during early digital convergence.

5.2 Practical Contributions

This research yields several actionable insights for practitioners and policymakers engaged in the development of XR ecosystem. First, original equipment manufacturers (OEMs) should recognize that technological dominance alone does not equate to effective ecosystem leadership. To foster adoption and generate sustained value, these actors must also cultivate inclusive governance frameworks, promote interoperability through open interfaces, and establish collaborative platforms that facilitate complementor participation.

Second, end-user organizations should move beyond expectations of stand alone XR solutions. Instead, successful implementation requires active engagement with technology providers, including the allocation of internal resources such as cross-functional teams and integration of 3D workflows. Such co-development practices are essential to tailoring XR applications to firm-specific operational contexts.

Third, public institutions and industry consortia have a critical role to play in supporting the ecosystem's structural maturation. Initiatives such as standard-setting bodies, public-private partnerships, and innovation testbeds can help mitigate fragmentation, de-risk experimentation, and accelerate the transition from pilot projects to scalable deployments.

5.3 Limitations and Future Research Avenues

Given the limited body of research on XR ecosystem emergence, this study employed an exploratory multiple case study approach to generate rich, context-specific insights. While this methodology offers depth, it is inherently susceptible to interpretive bias from both researchers and participants, which may affect the generalizability of findings (Yin, 2014). Future research could build on these insights by adopting quantitative or longitudinal designs to systematically examine how alignment, orchestration, and performance evolve over time.

Furthermore, the study's focus on the Italian XR market, characterized by its unique institutional and infrastructural conditions, limits the applicability of findings to broader contexts. Cross-national comparative research or studies on adjacent digital technologies (e.g., Blockchain, IoT) would help validate and extend the theoretical contributions, advancing a more comprehensive understanding of ecosystem emergence under conditions of technological uncertainty.

6. Conclusions

This study examined the emergence of the XR ecosystem within a technologically immature and structurally fragmented environment, emphasizing the strategic roles of incumbent firms and complementors. While technological progress, particularly in hardware and immersive content, has sparked enterprise interest (Porter & Heppelmann, 2017; Meccawy, 2023), the ecosystem remains in a formative state. The findings reveal that the absence of clear governance structures, interoperable standards, and a defined orchestrator hinders coordination and delays broader adoption. Complementors, lacking guidance and facing high uncertainty about which technological trajectory to support, are reluctant to commit, further stalling ecosystem consolidation (Kapoor & Agarwal, 2017).

Importantly, the study highlights how ecosystems led by powerful incumbents may face unique barriers in their early stages. Rather than fostering alignment, overlapping and uncoordinated orchestration efforts can exacerbate strategic ambiguity and fragmentation (Thomas et al., 2022; Lingens & Huber, 2021). This insight

extends existing research on digital business ecosystems by showing that incumbent participation alone is insufficient to ensure effective ecosystem formation. Even in contexts where technologically and financially strong firms are involved, the lack of clear orchestration can lead to inertia and misalignment (Hanelt et al., 2021; Senyo et al., 2019).

To overcome these challenges, the XR ecosystem requires collaborative orchestration mechanisms that promote open standards, inclusive governance, and multilateral coordination (Adner, 2017; Jacobides et al., 2018). Such structures are essential not only to guide complementors but also to reduce risk and support the transition from experimentation to institutionalized deployment (Moore, 1993; Nambisan & Sawhney, 2011).

Overall, this study contributes to ecosystem theory by shedding light on the complex interplay between orchestration, alignment, and actor interdependence in nascent technological domains. It also offers actionable implications for managers, policymakers, and developers seeking to navigate and shape emerging digital ecosystems under uncertainty.

Ethics Declaration

This research is based on qualitative data collected through semi-structured interviews with professionals working in the extended reality industry. All participants were informed about the purpose of the study, and their participation was entirely voluntary. Data were anonymized to ensure the privacy and confidentiality of respondents.

According to the institutional guidelines and national regulations applicable at the time of data collection, formal ethical clearance was not required for this type of research. Nonetheless, the study was conducted in accordance with the ethical principles and followed best practices for responsible research involving human participants.

AI Declaration

Artificial Intelligence tools were employed during the preparation of this manuscript to enhance the overall writing quality. Specifically, AI was used to improve linguistic clarity, rephrase content for better readability, and correct grammatical and stylistic errors. The intellectual content, analysis, and conclusions remain entirely the product of the authors' original work, and AI was not used to generate substantive ideas or interpret empirical findings.

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