Typology of Civil Society Engagement in Quadruple Helix Model Collaboration: A Systematic Literature Review

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Abstract

The growing recognition of civil society's importance in innovation has led to emergence of Quadruple Helix model that conceptualized civil society along with academic, government and business as the core stakeholders in innovation system. Despite its rising prominence, the concept of civil society in innovation remains undertheorized and convoluted, causing challenges in operationalization of Quadruple Helix in research and policy context. This research aims to address this gap by developing a typology through systematic literature review to identify the core dimensions of civil society engagement in Quadruple Helix. Two core dimensions of civil society manifestations and issue domain are selected based on thematic synthesis of 61 academic literature. The typology proposed 15 distinct types of civil society actors that derives from five groups of civil society manifestations and three stream of issue domain engagement. The typology provides conceptual lens for academic in operationalizing Quadruple Helix research and practical frameworks for policymakers in designing policy engagement with civil society.

1. Introduction

Involvement of civil society in innovation has attracted considerable growing interest over the past two decades. The increasing prominence of civil societies within innovation studies is reflected by the emergence of the Quadruple Helix model, which expands the Triple Helix model by positioning civil society as a distinct innovation actor alongside universities, industry and government (Carayannis and Campbell, 2009). The inclusion of civil society signals a paradigm shift from the technocratic or market-oriented approach emphasised in earlier innovation system frameworks. For instance, the Triple Helix Model, as conceptualised by Etzkowitz and Leydesdorff (2000), is often framed in the context of accelerating the transformation of university knowledge into industrial applications or marketable products.

This shift represents a departure from the established innovation system paradigm, in which the important role of civil society is largely muted or framed as a passive consumer of innovation. In emerging areas academic research such as citizen science, responsible research and innovation and grassroots innovation have demonstrated that civil society can act as a powerful agent in driving innovation. This inclusion of civil society however, add another layer of complexity in innovation system which relates to the nature of civil society as a sector that widely acknowledge as heterogeneous and complex (González-Martinez et al., 2021; Cai and Lattu, 2022; Nguyen and Marques, 2022).

The civil society heterogeneity complicates the fourth helix definition and introduces ambiguity into the conceptual clarity of the Quadruple Helix model. The heterogeneous nature of the sector presents practical challenges both in policies and research contexts for the operationalisation of the Quadruple Helix model. For instance, civil society actors inherent diversity has been suggested to complicate engagement with other helices and hinder effective collaboration governance (Nguyen et al., 2022). From policy perspective, this ambiguity also undermine policy objectives and the implementation processes. Matland (1995) ambiguity-conflict model highlight that a high level of policy ambiguity can lead to variable and context-dependent implementation outcomes. This suggests that the importance of civil society's clear and well-defined conceptualisation for policy implementation success. Conceptual ambiguity also poses risks to the scholarly work, as unclear boundaries compromise both research validity and understanding of the phenomenon (Bringmann et al., 2022). Yet despite growing call for greater conceptual precision of civil society, existing scholarship on civil society inclusion in innovation has not addressed these issues. Extant literature often focused on the method of engagement, governance strategies and micro-level dynamics. To address this critical gap, this research investigates characteristics that define the civil society's conceptual boundaries and its role in innovation. To that end, this research is guided by the following research question: What analytical dimensions define civil society as a distinct helix in quadruple helix collaboration?

To address the research question, this study conducted a typology development process to develop a systematic classification system and a theoretically driven organisation of civil society concepts in the context of innovation. Typology development is chosen because of its advantages in defining multiple patterns, which allow specification of nonlinear cross-construct relationships and incorporation of multiple attributes into a holistic definition (Doty and Glick, 1994). Furthermore, as Bailey (1994) argued, a typological approach facilitates an exhaustive and parsimonious understanding of the cases, making it well-suited to analyse the complex and heterogeneous nature of civil society organisation within the Quadruple Helix. This paper makes multiple theoretical contributions as follows: first, it improves the conceptual clarity and analytical boundaries of the civil society sector as a distinct actor in the innovation process through a typology development. Second, the typology provides a theoretical lens for academics and policymakers to systematically understand core characteristics of different types of civil society sector actors for the operationalisation of research and policies.

2. Literature Review

Civil Society as Innovation Actor

In innovation studies, civil society has been acknowledged as actor innovation actor that possess unique capacity and play crucial role in generating a distinct type of innovation. For example, Hossain (2016) points out that civil society actors such as local communities and nonprofit organisation are the main source of grassroots innovation which described as novel bottom-up solutions that respond to the local context and interest of relevant communities.

Civil society prominent role is not limited within grassroot innovation context as civil society's contribution is featured across several interrelated research stream. This is reflected in citizen science literature in which civil society featured as a key source of new knowledge through public participation in scientific experiment to address real-world problem (Moedas, 2018). Similarly, in social innovation stream civil society power is recognised as the important driver of community energy initiatives in European countries such where community owned renewable energy has reconfigure social practice of citizen from mere passive user into active partners in energy management (Hewitt et al., 2019). Taken together, these strands of literature firmly illustrated that civil society is indeed important contributor to innovation.

One key issue that arise from the diverse and cross-cutting contribution of civil society in innovation as discussed above is that the convoluted nature of civil society. Consequently, this issue raises an important question about what exactly civil society are? To answer that question, it is necessary to first briefly examine how civil society conceptually developed and evolve overtime. The origin of concept itself rooted in *koinonia politike (*political community), coined by Aristotle to refer to a moral community of the social realm (Anjum, 2010). The term *koinonia politike* conceptualised by Aristotle as a sphere in which men were able to achieve moral status (Anjum, 2010). From this perspective, civil society was viewed as a distinct sphere of society, which was characterised by civilised norms and values (Edwards, 2009). However, in the contemporary context, the concept of civil society is often associated with the 'third sector' of society, which consists of a web of associations that is distinct from the state and market. This common definition shares Gramsci's conception of civil society as diverse types of non-government and non-market institutions (Katz, 2006). From this approach, the definition of civil society shifts from 'sphere' within society to a group of actors that operate within that sphere. This brief conceptual examination show that civil society is historically a contested and diverse concept whose meaning changes over time.

From the concept historical examination, it is evident that innovation studies adopted the perspective of civil society as a group of actors. Within this perspective, civil society encompasses diverse types of organisations which include local communities, non-governmental organisations, cultural associations, parties, trade unions, religious organisations, and voluntary organisations. (Kohler-Koch and Quittkat, 2009). Given this scope, civil society is inherently diverse in terms of its form, mission and activities. In terms of its organisational scale, civil society ranges from a global-scale network to a local-level community association (Kaldor, 2003; Anheier and Themudo, 2002; Fontan et al., 2009). Nugroho (2011) categorised civil society organisations into two spectrums: those engaged in development issues at one end and social movement issues at the other. The development type is characterised by the civil society organisations (CSO) focus on activism in issues of welfare, environmental issues, and education. The social movement, on the other hand, works on the issues of civil rights, grassroots activities and political movements. (Fung and Wright, 2001).

The inclusion of civil society as an innovation actor stems from the second approach, which acknowledges the importance of the 'third sector' actor input and roles in the innovation process. For instance, scholars highlight that civil society has a critical contribution

to social capital and unique expertise (e.g., grassroots network and local knowledge) that is essential for the innovation process and diffusion (Fukuyama, 2001; Skidmore, 2001; Borah et al., 2023). A significant stream of literature also highlights that civil society is a central component in the dynamic innovation process as an important source of information and feedback in the development of the innovation process. This is reflected by the centrality of civil society in innovation frameworks such as living lab and co-creation that are increasingly adopted in European countries(Nguyen and Marques, 2022; Dias and Salmelin, 2018; Frow et al., 2015; Voorberg et al., 2015). In addition, another strand of literature suggested that civil society actors are particularly salient innovator in less economically developed regions. For instance, Williams and Woodson (2012) multi-case study demonstrates that NGOs play a key role in driving innovation through strategic mobilisation of organisational capabilities and expertise to implement technology-led solution in improving their beneficiaries wellbeing in Africa and India. This study reinforce Chesbrough et al. (2006) work that show that NGOs in developing-countries context are critical sources of new technologies in a world where government support are limited and private sector is restricted absence of supporting infrastructure.

Quadruple Helix Model

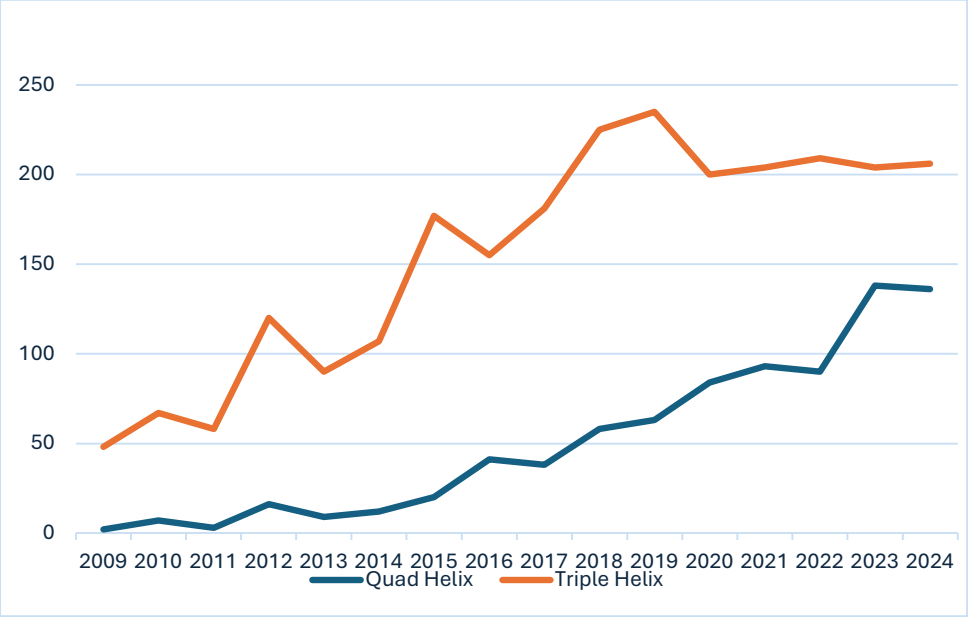
The Quadruple Helix model is a concept that introduces the explicit inclusion and integration of civil society into the innovation framework. Quadruple Helix is conceptualised as a recursive, interactive process and dynamic relationship between universities, industry, government and civil society as a means to drive the integration of knowledge and produce innovation (Carayannis and Campbell, 2009). The emergence of the Quadruple Helix is preceded by the development of the Triple Helix model, which focuses on trilateral collaboration to streamline production of scientific knowledge and its translation into technological advancement, economic growth and national competitiveness. Nevertheless, scholars have argued that the Triple Helix innovation framework fails to reflect the importance of societal actors' participation in the backdrop of increasing concern about sustainability (Etzkowitz and Leydesdorff, 2000). Quadruple helix, in this sense, responds to such criticism by shifting the innovation framework focus to civil society by adding it as an integral part of the overall model and positioning it as the ‘fourth helix’ (Cai and Lattu, 2022).

Carayannis and Campbell, the progenitors of Quadruple Helix, define the fourth helix as media-based and culture-based public, which plays the role of reflecting how public reality is constructed and communicated within the innovation and knowledge production system (Carayannis and Campbell, 2009). Carayannis and Campbell's original conceptualisation of the fourth helix as media or culture-based public is grounded on the idea that it is necessary to reflect the dynamics of democracy and pluralism of knowledge modes. This concept was later expanded by subsequent scholarly work on Quadruple Helix, which interprets the fourth helix in a more diverse manner, encompassing users, citizens, grassroots communities, non-profit organisations, social enterprises, and intermediary organisations. This diversity of interpretation of the fourth helix has been criticised by scholars as it lacks conceptual clarity and lack of focus. For instance, (Leydesdorff, 2012) view that civil society does not share the

characteristics of other helices, and such inclusion as an additional strand is problematic. Such scholarly debate underscores the problem of civil society diversity that requires more research to systematically dimension civil society characteristics in quadruple helix operationalisation (Cai and Lattu, 2022).

The Quadruple Helix model proved to be popular in scholarly work, as shown in Figure 1 the body of literature growing consistently from 2009 to 2024. From a scholarly viewpoint, the Quadruple Helix model has been adopted in various research streams such as smart city (Borghys et al., 2020; Marchesani and Ceci, 2025), living lab (Nguyen and Marques, 2022) and social innovation (Nordberg et al., 2020). In addition, from the policy side, there are notable policies and initiatives that integrate the principles of academia, industry, government and civil society, dynamic engagement in the innovation process, such as the Smart Specialisation Strategy (Carayannis and Grigoroudis, 2016).

Figure 1 – Quadruple Helix and Triple Helix Publication Trend



Source: Author's own construction, based on data retrieved from Scopus and Web of Science (2025)

3. Methodology

This study's systematic literature review followed Tranfield et al.'s (2003) three-stage process of planning, conducting the review, and reporting and dissemination. To identify relevant literature, a pilot study using the search term "civil society" AND "Quadruple Helix" as the central key concept of this research was conducted through the Web of Science Core Collection (WoS). For the pilot review, an initial set of ten most-cited articles was selected. Following the pilot review, the full search string was updated, as presented in Table 1. Relevant literature was collected from Scopus and Web of Science Core Collection using this search string. The search results filter was applied to publications in English, published between 2009 and 2025. 2009 was selected as the starting point, considering the foundational work on the Quadruple Helix was published in 2009. The review was also restricted to peer-reviewed

journals. This is to ensure the quality and consistency, given that the peer review and editing process is more varied for other types of publication.

Table 1 – Search String of Systematic Literature Review

Concepts	Keywords
Civil Society	"Civil Society" OR "Civil Society Organisation" OR "CSO" OR "Non-governmental Organisation" OR "NGO" OR "Voluntary sector" OR "religious organization" OR "faith-based organisation" OR "charity organisation" OR "association" OR "citizen" OR "community"
Quadruple Helix	"Quadruple Helix" OR "Multi-helix" OR "Multihelix" OR "university, industry, government and civil society" OR "university-industry-government-civil society" OR "academia, industry, government and civil society" OR "academia-industry-government-civil society" OR "university-business-government-civil society" OR "university, business, government and civil society"

Source: Author

The search returned 399 articles, of which, after removing 123 duplicates, a total of 276 papers were included in the first phase of screening by reading the article titles and abstracts. In this first phase, the paper inclusion was assessed based on two criteria. The first criterion was that the article topic focused on civil society engagement with other actors (university, business or government). The second criterion is that the article explicitly frames the aim of the actors' collaboration as being in pursuit of knowledge production or innovation. The title and abstract screening phase resulted in 181 articles being discarded, and 95 articles were retrieved for full-text review. The full-text screening applied the same criteria as the title and abstract screening to confirm that each study was relevant. In addition, the methodology of the study was also evaluated to discard studies with unclear methodology. This second phase resulted in 34 articles being discarded and 61 being included as the final dataset. The final set of articles served as the basis for the development of relevant dimensions by extracting conceptual definitions and empirical findings concerning civil society engagement in the Quadruple Helix through an open coding process. The open coding result was then categorised through iterative steps of axial coding to identify the emerging pattern and categorise similar dimensions within the same category. For instance, codes such as "end-user" and "customer" were refined into an overarching category of user.

Following the coding process and thematic analysis of the systematic literature review, the present study adopts Bailey's, (1994) approach as a framework to develop a multidimensional typology of civil society engagement. This research used the hybrid strategy that combines the inductive process of drawing recurring civil society engagement patterns from the reviewed literature and the deductive process that used theoretical grounding as the basis of the typology construct. The rationale for using a hybrid strategy rests on the consideration that systematic literature review comprises both empirical observation, which reveals observable engagement patterns, and conceptual discussion, which provides the theoretical grounding to construct the typology. It is important to note that while Bailey's approach does not explicitly prescribe the step-by-step process for developing the typology, three core principles of typology development can be identified. The first one is the identification of a fundamental characteristic of a phenomenon that utilises prior knowledge

and theoretical guidance to identify that key characteristic (Bailey, 1994). The second is substruction, which involves extending the dimensions of a single type to form the full typology by identifying the underlying dimensions that were used to create that specific type (Bailey, 1994). The third one is reduction, which involves reducing the number of types to a manageable level by eliminating, collapsing or merging dimensions (Bailey, 1994).

Applying Bailey's core principles, the first stage of typology development involves the selection of key dimensions from the thematic synthesis of characteristics that describe civil society engagement in the included literature. The key dimensions were selected based on three key criteria: 1) theoretical abstractions that capture a distinction that is meaningful within Quadruple Helix literature to ensure the dimension remains relevant to the field discourse (Paré et al., 2015); 2) empirical relevance, which reflects the recurrence of the themes across the reviewed literature (Kluge, 2000); and 3) distinctiveness, which reflects the nonoverlapping factor between selected dimensions, maximising within-group homogeneity and between group heterogeneity (Bailey, 1994). Based on those criteria, two core dimensions, civil society manifestation and issue domain, were selected to form a multidimensional property space that represents the possible combination of selected dimensions. Next, each cell within the property space was assigned a descriptive label that captures its defining configuration of dimensional values. The last step is the evaluation of the proposed typology. This was carried out by examining the degree to which conceptual types correspond to identifiable cases in the reviewed literature through the assignment of each article to a type in the property space.

4. Findings

Application of a systematic typological development procedure to the corpus of literature enabled the identification of themes that characterise civil society in the Quadruple Helix context. Further, based on the case analysis, clustering process and cross comparison of each group, two dimensions emerge as the core construct for typology, namely, manifestation and issue domain.

4.1 First Dimension – Form of Manifestation

The first dimension is manifestation, which refers to the empirical expression of civil society from an abstract concept in the Quadruple Helix framework. Identification of manifestation as a core dimension in this study follows an inductive logic grounded in the thematic synthesis of systematic analysis of the Quadruple Helix literature. The analysis first examined how civil society is defined and differentiated across the literature and identified five recurring themes through which civil society manifests within Quadruple Helix collaboration, namely: citizen, user, community, association, and NGO. These different manifestations and their core attributes are summarised in Table 2.

Table 2 - Group of Civil Society Actor Types and Core Attributes

Attributes	Citizen	User	Community	Association	NGO
Organisational Structure	Represent an atomised and disorganised	Represent atomised and disorganised	Spectrum of semi-organised to	Formally organised and clear	Professionally organised with dedicated staff

	form of civil society	form of civil society	organised and governed organically	governance process by its member	and institutionalised structure
Orientation	Broad civic interest and citizenship right	Functional demand-side relationship with product, service or solution	Solidarity and shared identity based	Membership based and representation of its member interest	Mission-driven and institutionalized goals
Formality of Engagement	Informal	Informal	Semi-informal to Formal	Formal	Formal
Knowledge Contribution	Individual voice and experience	Tacit user knowledge and experiential feedback	Contextual knowledge and shared experience	Collective and aggregated sectoral, professional or constituency knowledge	Issue driven interest and expert expertise
Theoretical Basis Tradition	(Swyngedouw, 2005)	(Von Hippel, 1986)	(Moulaert and Sekia, 2003)	(Swan and Newell, 1995)	(Salamon, 1987; Chesbrough et al., 2006)

Source: Author

These five manifestations represent the most consistent and distinctive form of civil society across the empirical corpus and are theoretically grounded in existing innovation studies literature. For instance, Swyngedouw (2005) Conceptual work on social innovation positioned the citizen as a distinct actor whose national citizenship and entitlement to political participation serve as the foundation of inclusion in the governance process. The civil society manifestation as a user is rooted in Von Hippel (1986) The concept of user innovation which frames the user as a distinctive innovation actor who develops and modifies products based on their own needs. Community, as a distinct civil society manifestation, draws its theoretical grounding from Moulaert et al. (2005) work that conceptualises community as a central actors for social innovation and local development in at the local level. Association as an innovation actor is grounded on Swan and Newell (1995) that highlight the role of professional associations in the diffusion of innovation through their boundary-spanning activity. Lastly, the theoretical basis of framing NGOs as innovation actors is based on a long-standing tradition in innovation studies such as Chesbrough et al. (2006) that highlight the crucial role of professional nonprofit organisations' contribution in driving technological innovation within the developing countries context.

Having identified these five manifestation themes from the literature, a further analytical process examined what underlying attributes can be used as a basis to consistently distinguish between one manifestation and another. This additional analysis is warranted to clarify the conceptual clarity of each manifestation. The examination of implicit and explicit features of different civil society manifestations reveals four core attributes that explain the differences between five manifestation themes across the literature. These four attributes are: centre of orientation, organisational structure, formality of engagement, and knowledge contribution. Organisational structure in this case refers to the degree of internal coordination and

governance arrangement through which civil society actors organise themselves. This attribute reflects a spectrum from disorganised forms of civil society at one end, through organically and loosely organised collectives, to formally structured and professionally managed organisations at the other. This core attribute has direct implications for civil society actors' capacity, capability, and power relations in the context of Quadruple Helix engagement (Albareda, 2018). Orientation refers to the basis of civil society identity and legitimacy to engage within the Quadruple Helix. This attribute captures the fundamental difference in the capacity of civil society actors involved and why their inclusion in the innovation system is justified. Differences in orientation are important as the basis for categorising different manifestations of civil society actors because they relate to the civil society legitimacy and the basis of other helices' engagement with civil society (Egholm et al., 2020). Engagement formality describes the degree to which a civil society actor is governed by formalised institutional arrangements, formal rules and procedures in their engagement with their counterpart. These attributes are related to organisational structure, but they are analytically distinct as they focus on the external relationship with other helices instead of internal governance of civil society itself. Engagement formality inclusion as a core attribute for determining civil society manifestation is grounded in its relationship with the depth and dynamics of engagement with other helices (Nordberg et al., 2020). Lastly, knowledge contribution relates to the type of knowledge that civil society actors contribute to the innovation system within the Quadruple Helix. This core attributes inclusion is important from an innovation system perspective as it provides a theoretical lens of civil society inclusion based on its knowledge and insight contribution (Carayannis and Rakhmatullin, 2014).

4.2 Second Dimension – Issue Domain

The issue domain is the second dimension for this typology, which refers to the broad area of concern that becomes the focus of civil society engagement in collaboration with academia, industry or government actors. Based on the analysis of the corpus of data, there are three distinct issue domains of civil society within Quadruple Helix, namely: economic, social and wellbeing, and environmental.

Economic issue domains in context, the civil society engagement with the innovation process consists of two streams. First stream focused on improving economic conditions or solving economic problems, such as labour skills, employment, entrepreneurship, and financial inclusion, while the second focused on identification and exploitation of market opportunities (Costa et al., 2023; Fuster Morell and Senabre Hidalgo, 2022; Butt et al., 2023). The first stream of economic domain represents a divergence from the mainstream lenses of market-driven or state-led economic and innovation initiatives, which lack civil society voice in the process. Further, involvement of civil society in the economic issue domain serves a critical function of intermediary and advocacy functions to translate the lived economic realities of wider society into inputs that shape the innovation agenda (Nguyen et al., 2022; Rogelja et al., 2025). This civil society function is important to correct a structural bias in traditional economic and innovation agenda setting that often focuses on the high technology sector and overlooks society's grassroots needs (Bhattacharjya et al., 2023). In contrast to the

first stream, the second stream is more aligned with the market-driven or state-led innovation initiatives, which frame civil society engagement as a crucial way to unlock opportunities and accelerate market exploitation.

Civil society, which is involved in this issue domain, often represents the economic interests of underprivileged or underserved populations, such as rural communities, elderly citizens, informal workers, and small and medium enterprises (Butt et al., 2023; Nordberg et al., 2020; Ziakis et al., 2022). Theoretically, the involvement of civil society in the economic domain can be seen as a market failure correction mechanism. Arrow's (1962) notion of knowledge possesses public good characteristics, which implies that the private market will chronically underinvest in the production and diffusion of innovations for a certain segment of the population. For instance, Bhattacharjya et al. (2023) The case study shows that civil society involvement in Quadruple Helix collaboration is crucial for the co-creation of frugal innovation for the unorganised sector and marginalised populations.

Turning to the environmental issue domain, civil society engagement within the Quadruple Helix in this issue focuses on various aspects of environmental sustainability, which range from circular economy development, sustainable energy management, climate change adaptation, and natural resource management (Rogelja et al., 2025; Battisti et al., 2024; Nijkamp et al., 2023). Involvement of civil society in environmental issues reflects the public's growing awareness of the importance of environmental quality as a public good, for which collective participation by society in its governance beyond market mechanisms and state regulation is necessary to ensure it sustainability (Nijkamp et al., 2023). This notion of environmental sustainability as public goods establishes justification for civil society as a crucial part of the political-economic system to participate in this environmental domain of the Quadruple Helix.

There are two distinct streams of literature on the role of civil society in the environmental domain, each stream distinguished by its orientation. The first one primarily orients civil society as a governance actor within existing innovation systems. In contrast, the second stream orients civil society as a transformative agent that drives sociotechnical change. In the first orientation, civil society actors represent the voice of environmental sustainability to articulate public environmental values and integrate these values into the innovation process governance that would otherwise be indifferent toward such values. Therefore, civil society's role in this context is positioned as a critical counterweight to the market-driven or state-directed innovation system that often overlooks environmental considerations. This framing for civil society role is present in multiple civil society manifestations, from citizen engagement in smart cities projects to local community stewardship. However, this domain is particularly prominent in NGO’s activity as advocates and as watchdogs of public interest in implementing sustainable practices. The second stream of literature framed the civil society's role in this domain not merely as an actor that articulates environmental values but as the transformational agent that brings about a fundamental shift in the socio-technical system toward sustainability. This framing is grounded on a multi-level perspective of socio-technical systems and sustainability transitions. From sustainability transition theory, Markard et al. (2012) argued that such a transition requires a multi-level process to shift the established consumption and production socio-technical regime into more sustainable modes. The civil

society's role in driving this multi-level process is elaborated by Geels and Schot (2007) seminal work on the multi-level perspective of socio-technical system transition, which suggests societal pressure groups and social movements as the mechanism of transformation pathway in shifting socio-technical system regimes.

The last issue domain for this typology is social and wellbeing. This encompasses civil society engagement with other helices that are directed toward enhancing society's quality of life, which includes social inequalities, social exclusion, discrimination, access to education and health vulnerabilities. Within this domain, innovation processes and their respective output shift from a mainstream economic or technological centric perspective toward human-oriented and socially embedded dynamics. The nature of civil society participation in this domain can be distinguished into two distinct types. The first one is civil society as the embodiment of societal value and the representation to integrate such values in collaboration with other helices. In this perspective, civil society tends to be positioned as a partner that is invited by other helices into Quadruple Helix collaboration to obtain a societal perspective and feedback. This is reflected by the emphasis on civil society's role to identify the social and wellbeing problem, to co-create the solution with other stakeholders and to leverage the civil society network in addressing the societal challenges. The second type of engagement in this issue frames civil society as more active and central actors which drive the innovation. In these types, civil society often initiate and facilitates other helices to contribute to the Quadruple Helix collaboration. This kind of civil society engagement is particularly prominent in the context of social innovation.

4.3 Two-Dimensional Typology Analysis

The following subsection elaborates on each type of civil society within the Quadruple Helix based on a cross-cutting analysis of two core dimensions. The typology includes fifteen distinct types of civil society based on the form of civil society manifestation and associated domain focus. A proposed typology has been constructed, as shown in Table 3. The presented typology shows that each group has a different contribution in innovation process and motivation that drive each group's engagement. These differences carry important implications for how different manifestations of civil society actor play their role within the Quadruple Helix.

Table 3 - Two-Dimensional Civil Society Typology

Domain Issue **Manifestation**	**Economy**	**Environment**	**Social & Wellbeing**
Citizen	L: Economic welfare citizen M: Civic right to economic welfare C: Bottom-up need articulation	L: Environmental welfare citizen M: environmental civic responsibility. C: lived experience and place-based knowledge	L: Social welfare citizen M: social welfare right and civic responsibility C: grassroot level need articulation and social legitimacy
User	L: Economic value user	L: Eco-conscious users	L: Social value user

	M: Economic value from improved solution	M: environmental value from improved solution	M: social and wellbeing outcome
	C: demand-side functional feedback	C: market intelligence and social legitimacy	C: features and needs fit feedback
Community	L: Economic development community	L: Environmental stewardship community	L: Social development community
	M: Shared local economic interdependency	M: shared local environmental interdependency	M: shared local social interdependency
	C: Local knowledge and social capital mobilisation	C: Local knowledge and legitimacy	C: Contextual social knowledge and relational trust
Association	L: Economic advocacy association	L: Environmental advocacy association	L: Social advocacy association
	M: Collective economic aspiration	M: Collective environmental aspiration	M: Collective social interest representation
	C: Aggregated meso-level knowledge and member network	C: strategic reframing of environmental innovation agendas	C: facilitative mechanism to bridge constituencies member with other helices actor
NGO	L: Economic empowerment NGO	L: Environmental transition NGO	L: Social empowerment NGO
	M: Mission-driven economic equity advancement	M: mission-driven sustainability transition	M: mission-driven social development
	C: Facilitating grassroot innovation	C: Facilitating socio-technical regime transition	C:Proactive agenda-setting and other helix facilitation
Legend= L: Label, M: Motivation, C: Contribution			

Source: Author

Citizen-Based Actors Group

Citizen-based civil society actors constitute the first group within the typology. This group is characterised by civic orientation, organic and informal modes of engagement in innovation. Citizens in this context refer to individuals who engage with other helices not through organisational membership or affiliation but through their inherent capacity that draws from lived experience, knowledge and interest as members of the public. In other words, a citizen-based actors engage because of who they are in the political community. The conception of civil society as citizens resonates with Marshall and Bottomore's (1987) The idea of citizenship, which holds that an individual, as a member of a political community, gives legal powers in the community's decision-making. For example, Nguyen et al. (2022) study suggests that in the Catalan living lab case study, citizen participation is grounded on citizens' strong discursive legitimacy, which is justified by their right to be involved in innovation that will impact wider society. Therefore, citizen-based actors play their role in the innovation process not by generating technological solutions but by grounding innovation outcomes and processes on citizenship rights and civic values.

The first variant in this group, the economic welfare citizen, is positioned at the intersection of citizen and economy dimensions. This variant represents informal engagement by individual citizens in economic affairs that is grounded in their civic right to equitable economic welfare. They engage as stakeholders whose lives and economic welfare are shaped by the innovation trajectories. For instance, citizen involvement in the digital silver hub project is driven by the opportunity to contribute toward designing educational resources and training programs that are tailored to the needs of citizens to acquire new skills and retraining to remain in their employment (Butt et al., 2023). From an innovation dynamic perspective, this type introduces a bottom-up innovation flow through citizen contribution in articulating relevant needs and iterative feedback in the development of an innovative solution (Nijkamp et al., 2023; Butt et al., 2023; Skarzauskiene and Mačiulienė, 2021). This bottom-up innovation mechanism is a particularly important strategy to design public policy that resonates with citizen challenges and opportunities in economic affairs (Fuster Morell and Senabre Hidalgo, 2022).

The second variant, the environmental welfare citizen, is positioned at the intersection of citizen manifestation and the environmental issue domain. An environmental welfare citizen is driven by personal environmental concern and civic responsibility toward environmental quality as public goods, the basis for civil society involvement with the Quadruple Helix collaboration (Nguyen et al., 2022). Their engagement typically relates to place-based environmental challenges, where citizen engagement is seen as essential for the long-term implementation and maintenance of collaborative initiatives (Battisti et al., 2024). Environmental welfare citizen engagement in innovation includes participation in citizen science projects, living labs collaboration, and environmental policy consultations (Bally and Coletti, 2023; Nguyen et al., 2022; Skarzauskiene and Mačiulienė, 2021). Accordingly, environmental welfare citizens mainly play a participatory role that shapes the innovation trajectory. For instance, Nijkamp et al. (2023) demonstrating the individual citizen role in constructing a model for local energy policy in Rotterdam through the environmental policy consultation process. Therefore, within the two streams of the environmental issue domain, the environmental welfare citizen primarily operates within the governance stream rather than the transformative stream.

The third variant can be labelled as a social welfare citizen, which captures the citizen-based civil society participation in innovation that focuses on social affairs. The defining characteristic of this type is that the main motivation for civil society to participate in collaboration is to solve societal challenges as a civic actor whose engagement reflects a commitment to improve the social fabric of their civic community (Roman et al., 2020). Consequently, their contribution to innovation is different from the other two variants in terms of their focus on identifying problems and integrating citizen social perspectives on policy or solution design to address the identified social problem. What makes social welfare citizen engagement distinct from social value user types is that social welfare citizens position themselves as civic actor instead of someone who uses or directly receives benefits from the solution. Within the two main framings of social and wellbeing issue domains, socially engaged citizens are categorised as civil society actors who

embody the societal value instead of active agents of social innovation. In that sense, their innovation role is primarily positioned to anchor innovation agendas with civic values.

Theoretically, citizen inclusion as a manifestation of civil society derives from the Quadruple Helix framework's logic of inclusive and democratisation of innovation (Roman et al., 2020; Castillo-Vergara et al., 2024). All three variants within this group represent the basic and informal form of the fourth helix with involvement that is relatively detached from a specific institutional context, which is in contrast with other helices. This places citizens in a structural disadvantage and a power imbalance position relative to institutional actors' counterparts in academia, industry and business, leading to challenges in designing inclusive participatory mechanisms for Quadruple Helix collaboration with citizen-based civil society.

User-Based Actors Group

User-based civil society is the second group within the typology. In contrast to citizen, which is inclusion-based on individual civic standing in a political community, user inclusion is grounded on a functional relationship with a product, service or solution to capture demand-side insight into the innovation process (Malik et al., 2021; Höglund and Linton, 2018). User-based civil society actor inclusion into the innovation system reflects a broader paradigm shift from a supply-driven and expert-centred innovation approach toward demand-driven and user-centred innovation models. This shift is theoretically drawing from Von Hippel (1986) foundational work on the importance of involving lead users in innovation through experiential feedback and modification of existing solutions. The defining characteristic of user-based civil society actors across all three variants is their disorganised structure, functional orientation and informal mode of engagement (Schütz et al., 2019; Nguyen and Marques, 2022). Furthermore, three variants of user-based actors also share similar capabilities in their contribution to innovation by providing tacit user knowledge and experiential feedback into the development of innovative solutions that other helices frequently lack, thus making them a critical source of authentic demand-side intelligence (Bosch-Sijtsema and Bosch, 2015; Nielsen et al., 2016; Liedtke et al., 2012; Fursov and Linton, 2022).

Economic value user represents the fourth type of civil society within the Quadruple Helix, positioned at the intersection of user and economy dimensions. Unlike the economic welfare citizen whose engagement is driven by concern as a member of the public who is affected by broader economic development, their engagement is bounded by a narrow interest in a functional relation on a solution that is tailored to their specific needs (Hasche et al., 2020). Consequently, they primarily contribute to innovation by providing user feedback, identifying key features and unmet needs, or co-create with other stakeholders, whose information and collaboration are crucial to creating a solution that fits their needs (Costa et al., 2023). Economic value user main innovation function is most pronounced in iterative development of a product that directly shapes product-

market fit. Therefore, in terms of positioning within the two streams of economic domain perspective, economic value users are more aligned with the market exploitation stream rather than the market correction stream.

Eco-conscious user constitutes the fifth type of civil society actor within Quadruple Helix that is positioned at the intersection of user and environmental dimensions. Their innovation role primarily lies in embedding sustainability features into the design of marketable solutions. In contrast to the environmental welfare citizen who is characterised by their civic identity, eco-conscious users' engagement is bounded by their logic as consumers that place emphasis on sustainable product choice. Accordingly, eco-conscious users tend to contribute their knowledge and feedback as end users of the product to the development of environmentally sustainable solutions (Nielsen et al., 2016; Tukker et al., 2017). Therefore, their role within innovation is oriented toward embedding ecological considerations into socio-technical systems that develop new preferences and practices (Schot and Steinmueller, 2018).

Social value user represents the sixth type of civil society that is situated at the intersection of the user within social well-being dimensions. The distinction of social value users and social welfare citizens is that this type represents the direct recipients of the service. The social value of users' contributions toward innovation is grounded in user experience. They help identify and articulate user needs to create solutions that are oriented toward addressing social challenges or improving common well-being (Voorberg et al., 2015). This characteristic makes the social value user particularly suitable to design a product that aims to address social problems. Unlike economic value users, whose engagement is mainly driven by economic benefit or eco-conscious users who are motivated by environmental value, social-value oriented users are distinguished by their focus on broader social and well-being benefits. Consequently, social value users often operate within the context of social innovation or public policy design (Bovaird, 2007).

Community-Based Actors Group

Community-based actor sits in an intermediate position in the typology. They are located between informal and structurally fragmented forms of civil society at one end (e.g. civil society and user) and the formal and structurally aggregated forms of civil society at the other (e.g. association and NGO). Community-based actor groups in this typology include a broad spectrum of collectives from geographically bounded communities (i.e. village, local community) to shared aspiration-based communities (i.e. community of practice) (Bhattacharjya et al., 2023; Nordberg et al., 2020; Shyiramunda and van den Bersselaar, 2024). What unites this diverse collective as one grouping is a community-defining characteristic of collective shared identity, culture, space or interest as the basis of their internal bond and external coherence. This characteristic is also reflected in the community's engagement with innovation processes that are more collective than the functional demand-side relationship of users.

The seventh type of civil society could be labelled as an economic development community, positioned at the cross-cutting section of community and economy. This type is conceptualised as collective actors whose engagement in innovation processes is driven

by mutual stakes in local economic development impact that is intrinsically linked to the community constituencies' mutual interdependency with broader local economic trajectory (Castro-Arce and Vanclay, 2020). Their contribution to innovation is characterised by the mobilisation of local knowledge and social capital that is critical to identify relevant economic challenges, design community-fit solutions and leverage social acceptance for rapid diffusion (Grundel and Dahlström, 2016; Kayanan et al., 2022). This contribution is particularly relevant in an innovation context that involves locally based economic development initiatives such as rural or urban project development, smart specialisation strategy projects, and grassroots economic innovation (Armillei et al., 2024; Ward et al., 2021; Carayannis and Rakhmatullin, 2014).

Environmental stewardship community represent the eighth type, which constitutes a civil society actor located at the intersection of community and environmental dimensions. This type is characterised by its emphasis on a place-based focus on environmental sustainability, as the community environmental stewardship engagement is fundamentally collective and territorially embedded, rooted in a shared understanding of how environmental conditions shape community quality of life and long-term survival of the community (Pesch et al., 2019; Rogelja et al., 2025). Their role in innovation is to leverage contextual community knowledge and capacity, as demonstrated in community energy literatures (Hewitt et al., 2019). Consequently, environmental stewardship community involvement is driven by a collective interest in protecting and improving the surrounding environment of their community. The environmental stewardship community contributes to environmental innovation through participation, stewardship and diffusion of innovation (Rogelja et al., 2025). Within the environmental issue domain, the environmental stewardship community tend to be positioned in the governance stream with the role to specify and integrate community environmental value into innovation processes.

The social development community refers to a locally based informal group that engages in collective action to enhance social local wellbeing by collaborating with other helices. Social development community role in innovation is centred on their deep knowledge of local social conditions, relational trust and social capital to mobilise collective action and legitimacy to facilitate responsive social innovation (Borkowska and Osborne, 2018; Reficco et al., 2018). Territorial embeddedness of social development community provides them with context-specific insight that is often overlooked by other helices (Suarez-Balcazar et al., 2005). In addition, social development community relational trust with its constituencies represents a crucial source of social capital and legitimacy (Van Oers et al., 2018; Walker and McCarthy, 2010). Therefore, social development community contribution to the innovation system lies in their capacity to mobilise relational trust and rich contextual knowledge that support problem solving and facilitate engagement with other helices.

Association-Based Actors Group

Association-based civil society actors represent the fourth group within the typology. All three variants of association-based civil society actors share characteristics, which they

are predominantly formal organisational structure that formed around membership, shared interest, professional affiliation or common objectives (Malik et al., 2021; Newell and Clark, 1990). Association-based actor capacity to be involved within the Quadruple Helix derives from their members' shared interest and institutionalised commitment to represent their members' interests (Pestoff, 2012). Within the Quadruple Helix, association has a distinct role in aggregating the fragmented, dispersed and heterogeneous voice of an atomised form of civil society into an organised and collective coherence. With this distinct role and their formalised organisational structure, association-based actors can engage in a more formal and intensive mode of engagement with academia, industry and government helix actors compared to user, citizen or community civil society actors (Bovaird, 2007; Vrangbæk et al., 2018). This allows association-based actors the advantage to interact with other helices in more dynamic terms and be meaningfully involved in formal collaboration governance processes. At the same time, the association-based actor's formal structure and governance process also introduces representational risk, which may dilute the organic grassroots voice that they claim to represent (Bovaird, 2007; Dempsey, 2009).

The first variant of this group, the economic advocacy association, is positioned at the intersection of association manifestation and the economic issue domain dimension. This type represents a membership-based civil society group whose engagement within the Quadruple Helix is oriented toward advancing the economic interests of its constituency (Doner and Schneider, 2000). Examples include trade unions, farmer associations, cooperatives, small business associations and professional occupation associations, actors that structurally constitute a network of their members to consolidate shared aspirations and resources in a form that allows collective action (Marques, 2017). Therefore, the economic advocacy association tends to play an intermediary function to consolidate the fragmented aspiration individual members and translate such aspiration into organised advocacy capacity to exert its influence in shaping the Quadruple Helix dynamic. In terms of contribution, the economic advocacy association provide an aggregated form of micro-level economic reality of its members into meso-level institutional knowledge. Furthermore, this type contributes a distinctive form of social capital which derives from its member network.

The second variant of this group, the environmental advocacy association, is positioned at the intersection of association and the environmental issue domain. This type is characterised by its orientation toward collective environmental values and the sustainability commitment of its members. Within the two streams of the environmental issue domain, this type has been shown to operate in both governance and transition streams. In the governance stream, environmental advocacy associations advance the integration of collective environmental values into innovation processes. Further, this type contributes toward the governance of the Quadruple Helix by introducing a linkage to the association of collaborative networks. This environmental governance linkage provides a range of support functions, including knowledge broker, sustained governance and an important conduit for micro-level relationships that potentially create synergy between micro and meso-level for environmental stewardship (Pittaway et al., 2004). In

the transformative stream, this type assumes a more active role to bring about structural changes by pressuring the established system through collective mobilisation of its members and advocacy. By adopting this role, environmental advocacy associations contribute through strategic reframing of environmental innovation agendas and support transition of the sociotechnical system from the established regime toward the sustainable regime (Cashore, 2017).

The social advocacy association, as the last variant of this group, sits at the intersecting axis of association-based actor and the social well-being issue domain. This type performs a boundary-spanning function in the innovation process that is analytically distinct from its counterparts in the economic and environmental domains by its motivational orientation to advance the social and wellbeing interest of its members. This orientation inherently influences the nature of the social advocacy association's distinct contribution toward innovation. The first one is providing a representational mechanism to aggregate the dispersed knowledge and diverse needs of their members into legible, coherent input for setting social innovation agendas. However, this also comes with a representational risk and reinforces the minority of members' interests due to the diversity of social and well-being needs. The second contribution is related to the social advocacy association facilitative mechanism, which bridges civil society constituencies and other helix actors by translating social and well-being needs into technical, policy and market context and *vice versa*.

NGO Based Actors Group

Non-government organisations (NGO) are the last distinct manifestation of the fourth helix. NGO can be distinguished from the preceding types of civil society actors with its core attributes of professionalised structure, mission-driven orientation and formal modes of engagement within the Quadruple Helix. In terms of its structure, NGO typically have a formalised structure and clearly articulated governance processes. This formal structure and governance processes provides NGO the dynamic learning ability that is crucial for institutional knowledge accumulation and to meaningfully engage in the innovation process. The second NGO’s attributes of mission-driven orientation give them a distinctive source of legitimacy that comes from deep and unique expertise within their organisation's mission domain. Furthermore, NGO expertise in issues related to their mission gives NGO a greater institutional capacity and capability to engage in relatively more equal positions with actors from other helices, making them the civil society actors most capable of participating in complex innovation governance where other civil society types are structurally disadvantaged. However, this characteristic of NGO-based actors also introduces the representational risk of not fully representing grassroots interest and values, as this is diluted by NGO professionalised governance and organisational distance from grassroots actors.

Economic empowerment NGO is the variant of NGO-based actors’ groups that engage in the economic issue domain. This type is characterised by their orientation to advance the economic empowerment of the marginalised or underserved part of society (Nikkhah and Redzuan, 2010). They typically engage in projects that aim to improve

economic equity and inclusion, such as poverty eradication initiatives and digital economy inclusion projects (Lindberg et al., 2012; Heuer et al., 2020). The economic empowerment NGO contributes an expert knowledge in their subject area, policy expertise and strategic advocacy that can directly engage with other helices (Bhattacharjya et al., 2023; Nordberg et al., 2020; Rogelja et al., 2025). This positions economic empowerment NGOs as a potentially influential actor in innovation contexts. Within two streams of economic issue domains, NGO primarily operate in market failure correction rather than market opportunities exploitation. Specifically, economic empowerment NGO contribute to this stream by addressing the structural bias of the innovation system that chronically underinvests in the economic needs of those overlooked by the market and state (Bhattacharjya et al., 2023). For instance, this type is shown to facilitate grassroots innovation that is crucial to fill the market solution gap through connecting key contextual knowledge of their beneficiaries with other helices resources (Bhattacharjya et al., 2023).

The second variant of this group, the environmental transition NGO, sits at the intersection of NGO manifestation and the environmental issue domain. This type is arguably the most theoretically prominent civil society actor within the Quadruple Helix literature, given the extensive body of work on environmental NGO engagement in sustainability transitions, environmental governance and socio-technical regime change (Markard et al., 2012; van Welie and Romijn, 2018). This type is characterised by its strong orientation, which is driven by an explicit organisational mission toward environmental sustainability. This explicit organisational mission profoundly shaped environmental transition NGO engagement that tends to be formalised, more sustained and emphasises a strategic approach (Kourula, 2010; Kourula and Halme, 2008). The environmental transition NGO has contributed to the innovation system, which consists of their professionalised expertise, institutional knowledge, organisational capacity, public mobilisation and advocacy capacity (Pietronudo et al., 2025; Nahi, 2018; Dyck and Silvestre, 2019). This capacity and contribution reflect the environmental transition NGO position that holds dual streams to engage in the environmental issue domain, both as governance actors and transformative agents.

The last type, social empowerment NGO positioned at the intersection of the NGO group and the social and wellbeing issue domain. This type represents a formal and professionalised civil society actor whose mission is oriented toward advancing social development, wellbeing, justice, disability, access to education and healthcare (Tracey and Stott, 2017; Castro-Arce and Vanclay, 2020; Andrun, 2025). The social empowerment NGO tend to take a proactive approach compared to other actors in the social and well-being domain, as they are driven by organisational mission mandates and professional-level expertise in their domain area (Nordberg et al., 2020; Parthasarathy et al., 2021). This enables social empowerment NGO to position themselves as transformative agent in the social and wellbeing stream rather than the simple representation in governance of the Quadruple Helix. Indeed, this type has been shown to play a critical role in social innovation through combining contextual knowledge of their beneficiaries' social needs, professionalised organisational capacity and a wide network that consists of other helices actors (Oeij et al., 2019).

5. Discussion and Preliminary Conclusions

This study systematically investigates the heterogeneity of civil society within Quadruple Helix literature. This investigation is warranted as a response to a persistent gap in the Quadruple Helix literature that often acknowledges the fourth helix diversity but remains undertheorized (Cai and Lattu, 2022; Roman and Fellnhofer, 2022; Hasche et al., 2020). This study addresses that gap by developing a typology using two core dimensions, namely the civil society form of manifestation and the issue domain. In addition, the typology has specified four main attributes associated with the civil society manifestation form and two different categories for each issue domain. This typology systematically maps the heterogeneity of civil society actors that is often acknowledged in literature but lacks the framework to navigate this heterogeneity in research and policy operationalisation. This typology allows comprehensive analysis to establish a holistic understanding of civil society engagement with academia, government, and business in different settings.

The finding implies that civil society actors that are fit into the same group of manifestations share the same core attributes that shape the nature of their engagement in the Quadruple Helix. However, each variant of civil society actors in the same group displays differences in background motivation and contribution based on their issue domain. These findings explicitly demonstrate that structural form and motivational orientation function as independent determinants of civil society engagement within the Quadruple Helix. This challenges much of the Quadruple Helix literature that often overlooks civil society's structural configuration and its motivations as key considerations in explaining the fourth helix engagement within the Quadruple Helix model. For instance, an economic development community shares the same structural characteristics with an environmental stewardship community, but they are motivationally distinct in a way that each respective type has different knowledge contributions and different engagement mechanisms.

The result suggests a fundamental reconsideration of how civil society engagement within the Quadruple Helix is designed and evaluated. Participation of civil society and governance of the Quadruple Helix should not be based on the inclusion of unspecified civil society manifestations. The civil society actors that are included in the Quadruple Helix should be based on the aims of the Quadruple Helix collaboration and the expected contribution of the civil society. Furthermore, it is crucial to consider motivational profiling in selecting civil society representation in the Quadruple Helix, as it will shape the appropriate mechanism of governance and overall collaboration performance. This finding supports Rogelja et al. (2025) notion that application of the Quadruple Helix requires a combination of granular context-specific methods to guide power dynamics and internal diversity within the stakeholders. A Quadruple Helix model architecture that overlooks motivational orientation will likely underperform as it fails to leverage motivational logics that make the civil society contributions valuable.

This study aligns with the dominant stream of Quadruple Helix literature that civil society consists of heterogeneous actors (Roman et al., 2020; Rogelja et al., 2025; Nijkamp et al., 2023). The novelty of this study lies in the construction of a typology as a heuristic

lens to understand the complexity of civil society engagement within the Quadruple Helix. By focusing on manifestation as the first dimension of typology, it can be understood that civil society types exhibit distinguishable features. This diversity reflects the potential and challenges of navigating engagement with civil society, given that each type has distinct characteristics and implications for collaboration dynamics. The study further demonstrates in which ways each civil society actor type engages with a specific issue domain. Accordingly, this typology assists researchers and policymakers in understanding the implications of engaging a specific type of civil society actors within a specific issue domain. The understanding derived from this typology will then help researchers to design future research and policymakers to create better policies. Finally, the typology provides a solid foundation for identified future research avenues, such as examining the relevance of distinct types of civil society in empirical settings and the evaluation of engagement mechanisms for relevant types.

Theoretical and Practical Implications

This article contributes to the extant literature on Quadruple Helix, particularly on the theoretical framing of civil society participation and governance. The article proposes a typology that provides a conceptual lens to analyse the heterogeneous nature of civil society within the Quadruple Helix. Existing literature often focuses on a narrow subset of civil society, such as citizens, NGO, or users, but overlooks critical considerations in justifying the decision. The construction of a two-dimensional typology allows structural characteristics and motivational drive as key considerations explaining and examining different types of civil society engagement in the Quadruple Helix. The fifteen distinct types of civil society actors reveal future research opportunities to explore different strategies and mechanisms to engage with the corresponding type.

In terms of practical implications, the findings provide policymakers with a practical framework to guide two crucial decisions in designing and implementing Quadruple Helix policies or initiatives to enhance the policy-context fit. The first one is related to actor selection. The typology allows policymakers to identify what types of civil society actors to be included in the Quadruple Helix model project or initiatives. The basis of selection should follow the fit between a policy objective and a civil society actor's characteristics. For example, regional governments that want to engage with civil society to design policies that respond to local social needs can identify social welfare communities as potent strategic partners, as the civil society type of contribution and motivation is intrinsically aligned with the aim of the project. Second, on role clarity, the typology helps policymakers assign civil society actors to roles that match their capabilities and engagement modes. For instance, association-based actors or NGO-based actors are better positioned to take on shared governance roles given their greater organisational capacity. In contrast, a citizen-based actor is particularly suited to articulating grassroots-level needs.

Limitations

This study design in developing typology through systematic analysis of literature presents two main limitations that should be addressed in future research. The first

limitation is that the development of typology in this study only utilised secondary data from systematic literature analysis, which lacks empirical validation that can test the typology's applicability and utility in an empirical setting. Future research should examine whether the fifteen types are empirically distinguishable in practice and correspond with the different perspectives of each helix. The second limitation is related to the relatively static presentation of the fifteen civil society actor types, where in practice, civil society actors may change between these types or occupy multiple types simultaneously. This typology does not explicitly address this possibility and the dynamic of civil society types. Future research should develop a dynamic extension of the typology that theorises these phenomena.

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Exploring the Use of Generative AI in Nascent Entrepreneurial Work

Yihan Deng

1. Introduction

Nascent entrepreneurs frequently operate under conditions of uncertainty, limited resources, and time pressure. These conditions require them to interpret incomplete information, evaluate emerging opportunities, and make consequential decisions in environments where outcomes are difficult to predict.

At the same time, recent advances in generative artificial intelligence (AI) have introduced new digital tools that may influence how entrepreneurs approach everyday venture-related tasks. Tools such as large language models can assist with information search, idea generation, and problem exploration, potentially influencing how entrepreneurs structure their thinking and approach decision-making processes.

Despite increasing interest in artificial intelligence in management and entrepreneurship research, there is still limited empirical understanding of how entrepreneurs engage with these tools in practice. Much of the existing literature has focused on the technological capabilities of AI or on adoption at the organisational level. Less attention has been given to how entrepreneurs interact with AI tools in the day-to-day process of developing new ventures.

This study therefore explores how nascent entrepreneurs use generative AI tools during venture development. Rather than assuming specific outcomes or effects, the study aims to understand how entrepreneurs interact with these tools and how such interactions may influence their work practices and experiences.

2. Literature Review

2.1 Entrepreneurial Cognition and Decision-Making Under Uncertainty

Entrepreneurship is widely understood as an activity that involves interpretation, judgment, and decision-making under conditions of uncertainty (Shane and Venkataraman, 2000). Entrepreneurs

must make sense of incomplete information, recognise emerging opportunities, and evaluate possible courses of action in dynamic environments.

Research on entrepreneurial cognition highlights how these processes are shaped by heuristics, prior experience, and contextual factors (Baron, 1998; Mitchell et al., 2007). Entrepreneurs often rely on both analytical and intuitive reasoning when assessing opportunities and making strategic decisions (Busenitz and Barney, 1997; Sarasvathy, 2001).

At the same time, entrepreneurial work can be cognitively demanding. Founders frequently experience cognitive overload, ambiguity, and decision fatigue as they manage strategic, operational, and interpersonal aspects of venture development (Shepherd, 2015). These conditions make entrepreneurship a useful context for examining how individuals engage with tools that may assist with information processing or problem exploration.

2.2 Emotional and Psychological Experiences of Entrepreneurship

Entrepreneurship is not only a cognitive activity but also an emotionally demanding experience. Founders often operate under prolonged uncertainty, workload pressure, and financial constraints, which can contribute to stress and emotional strain (Stephan, 2018).

Prior research has documented a range of emotional experiences associated with entrepreneurial activity, including stress, exhaustion, loneliness, and the emotional consequences of setbacks or failure (Shepherd, 2003; Morris et al., 2012). These psychological experiences can influence how entrepreneurs approach decisions, evaluate opportunities, and persist in the face of uncertainty.

While research has examined emotional and psychological aspects of entrepreneurship, limited attention has been given to how emerging technologies may intersect with these experiences during venture development.

2.3 Artificial Intelligence in Entrepreneurial Work

Recent developments in artificial intelligence have generated increasing interest in how AI may influence organisational and entrepreneurial processes. In management research, AI is often discussed as a tool that can assist with information processing, analysis, and decision support (Raisch and Krakowski, 2021).

Generative AI tools are increasingly used for tasks such as drafting text, summarising information, and generating ideas. These capabilities suggest that AI tools may play a role in supporting certain forms of knowledge work.

However, existing research has primarily examined AI adoption at the organisational level or focused on technological capabilities. As a result, relatively little is known about how entrepreneurs themselves engage with these tools during the early stages of venture development.

3. Research Questions

Given the limited empirical understanding of how generative AI is used by entrepreneurs in practice, this study explores the following questions:

RQ1: How do nascent entrepreneurs use generative AI tools in their venture-related work?

RQ2: How do entrepreneurs describe their experiences when interacting with generative AI during venture development?

These questions aim to develop an initial understanding of how entrepreneurs engage with generative AI tools in everyday entrepreneurial activities.

4. Methodology

4.1 Research Design

This study adopts an inductive qualitative research design informed by grounded theory principles (Glaser and Strauss, 1967; Charmaz, 2014; Corbin and Strauss, 2015). Rather than beginning with predefined hypotheses, the research starts from the experiences of entrepreneurs and seeks to identify patterns that emerge from the data.

Qualitative approaches are appropriate for exploring emerging phenomena where existing theoretical explanations remain limited. In this study, the aim is to develop an empirical understanding of how entrepreneurs interact with generative AI tools in the context of venture development.

The research questions guide the interviews while allowing additional themes to emerge inductively from the data.

4.2 Sampling and Access

Participants will consist of nascent entrepreneurs involved in an accelerator or venture development programme. The study will focus on individuals who are currently developing early-stage ventures and who may have varying levels of experience using generative AI tools.

Approximately 30–40 participants are expected to be interviewed. Sampling will continue until the data provide sufficient insight into the phenomenon being studied.

4.3 Data Collection

Data will be collected through online semi-structured interviews lasting approximately 20–30 minutes. Interviews will focus on participants' experiences with generative AI tools during venture-related activities.

Participants will be encouraged to describe situations in which they have used AI tools when working on their ventures. Where possible, they may also be invited to describe specific interactions with AI systems to provide additional context for how these tools are used in practice.

The interviews will explore both perceived benefits and challenges associated with the use of AI tools in entrepreneurial work.

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PhD Science, Technology and Innovation Policy – IMP Division

Systematic Literature Review – 1st Draft

Diagnosing Digital Payment Barriers in Developing Economies: A Systematic Literature Review and Socio-Tech Payment Stack Approach

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*** Disclaimer**

Generative AI tools such as Co-Pilot and ChatGPT 5 were employed to support idea development and preliminary brainstorming during the preparation of this document. Grammarly was used to enhance clarity and linguistic consistency. The author has independently reviewed, validated and approved all final material.

Diagnosing Digital Payment Barriers in Developing Economies: A Systematic Literature Review and Socio-Tech Payment Stack Approach

Abstract

Purpose
This paper aims to examine the barriers that hinder the adoption and effective use of digital payment systems in developing economies by integrating insights from socio-technical systems thinking with a layered payment technology stack perspective.

Design and methodology
A systematic literature review was conducted in accordance with established PRISMA review standards. The review included 40 peer-reviewed studies published between 2010 and 2025 and was identified through a structured search across major academic databases, screened using explicit inclusion criteria, and analysed using a combined human-coded and AI-assisted qualitative synthesis process. The thematic findings were then organised within a socio-technical payment stack framework to classify barriers across user, organisational and infrastructural layers.

Findings
The review highlights 41 distinct barriers which cluster into eight thematic domains, including user capability constraints, social and cultural influences, trust and security concerns, weak consumer protection, infrastructure limitations, regulatory frictions, ecosystem fragmentation and organisational capability gaps. The integrated framework reveals that many obstacles commonly attributed to user reluctance originate from deeper systemic misalignments across institutions, technology foundations and organisational processes. The analysis explains why cash persists as a coherent default in many settings, while digital payments depend on multi-layer alignment that is often fragile.

Originality and value
This study offers one of the first attempts to link detailed barrier evidence from developing economies to a socio-technical payment stack, providing a diagnostic structure that clarifies where constraints arise and how they interact. It contributes a framework that helps policymakers, regulators, and industry actors identify leverage points for intervention and underscores that overcoming digital payment barriers requires coordinated improvements across layers rather than isolated demand-side or technical measures.

Keywords: Digital payments, Socio-technical systems, Payment technology stack, Financial inclusion, Emerging economies, Systemic barriers, Systematic literature review

1. Introduction

Digital payment technologies are redefining how transactions occur worldwide, with many economies shifting from a reliance on cash to electronic payment systems enabled by broad internet access and expanding mobile infrastructure (Birigozzi et al. 2025). Digital payments refer to transactions executed through digital or online channels without the physical exchange of cash. This definition encompasses a broad range of payment methods, including mobile money transfers, electronic wallets, online banking transactions and various forms of digital currencies (Khando et al. 2023).

The global digital payments market has expanded rapidly in recent years, driven by increased smartphone adoption, the rise of electronic commerce, evolving consumer preferences and continuous technological innovation. The COVID-19 pandemic further accelerated this surge by pushing industries and consumers toward contact-free payment options. Global non-cash transaction volumes grew significantly in the years leading up to the pandemic, and the total value of digital payments worldwide reached several trillion dollars at the start of this decade. These trends signal a new normal in which digital payments are becoming integral to daily life and economic activity (World Bank 2022; Yahoo Finance 2022; McKinsey & Company 2024).

Despite this rapid growth, the shift toward digital payments has been uneven across regions and population groups (Ricci et al. 2025). In many emerging markets, digital payments have not yet fully replaced cash, which remains a widely trusted means of payment and store of value. Public demand for cash has stayed relatively stable even as digital alternatives proliferate, reflecting deeply rooted habits and slow-changing payment cultures (Sadok and Elouaourti 2025). At the same time, a significant segment of the population in developing economies remains unbanked or underserved by formal financial services. This creates substantial opportunities for digital payments to bridge financial inclusion gaps, but realising this potential requires overcoming serious contextual challenges (Dafri and Al-Qaruty 2023; Gomber et al. 2017; Barroso and Laborda 2022a; Basnayake et al. 2024; Ediagbonya and Tioluwani 2022). Emerging economies, therefore, stand at the forefront of both the greatest opportunities and the greatest hurdles in the digital payment transition.

1.1 Importance of Digital Payments

The rise of digital payment technologies carries important implications for economic development and financial inclusion, especially in emerging markets. At the most immediate level, digital payments offer greater convenience and efficiency than cash. They enable faster transaction execution, reduce the need for physical handling of money and provide anytime, anywhere access to financial services. By dematerialising transactions, digital payments lower the costs associated with cash management, including printing, storage, insurance and transportation. For consumers and merchants, digital instruments can significantly enhance ease of commerce, for example, through instant mobile transfers or quick tap-based card payments, thereby improving the user experience in everyday transactions (World Bank 2023; Brown et al. 2022; Calderon 2024; Rachapudi 2022).

Beyond offering ease of use, digital payments are increasingly viewed as a powerful mechanism for expanding financial inclusion and supporting broader economic progress (Ly and Ly 2024; Ediagbonya and Tioluwani 2022; Khando et al. 2023). Through the use of mobile and internet technologies, digital payment platforms can extend financial services to groups that have long remained outside the formal banking system (Aracil et al. 2025). Even relatively simple mobile payment services allow unbanked individuals to store value safely, send and receive funds, and participate in the digital economy (Shaikh et al. 2023). Such services act as an entry point to financial inclusion, connecting underserved communities to payment networks and, over time, to additional financial products such as savings, credit and insurance (Ly and Ly 2024; Rachapudi 2022)

The adoption of digital payments also expands market access and participation for different economic actors. Small merchants can reach more customers by accepting mobile or online payments, while

consumers gain access to a wider range of sellers and services beyond their local area (Reinartz et al. 2019). At the macro level, digital payments generate positive externalities for the wider economy and the public sector. Moving transactions from cash into traceable digital channels improves transparency and accountability, reduces the size of the informal economy and can increase tax revenues (Mosco 2024). Formalisation of payment flows reduces economic friction, for instance by lowering leakage in government transfer programmes and improving record keeping for firms (Uña et al. 2023). In the longer term, higher use of digital payments is associated with increased spending and consumption, which can stimulate production, employment and growth (Birigozzi et al. 2025).

Digital payments also stimulate innovation and competition in financial services (Barroso and Laborda 2022b). Financial technology start-ups and other non-bank providers often enter the market through payment innovations, offering new solutions and business models such as peer-to-peer payment apps or buy now pay later services (McKinsey & Company, 2024.). Their presence can push incumbent institutions to modernise legacy systems, improve service quality and reduce fees. Therefore, the importance of digital payments lies not only in the convenience they offer individual users, but also in their broader socio-economic impact through enhanced financial inclusion, greater transparency and more dynamic financial markets (Birigozzi et al., 2025).

It is important to recognise, however, that these benefits do not emerge automatically. Realising the promise of digital payments depends on tackling the barriers that prevent individuals, firms and governments from adopting and effectively using these technologies (Singh and lakra, 2025). While digital channels can, in principle, include low-income and marginalised groups in financial systems, many still face obstacles related to access, connectivity, affordability and digital literacy (Tay et al., 2022). Understanding both the positive potential and the practical barriers of digital payments is therefore crucial for policymakers and other stakeholders seeking to harness digital finance for development.

1.2 Research Motivation, Gap, and Contribution

The global expansion of digital finance is driven by its promise to enhance economic efficiency and broaden financial inclusion (Ozili, 2018). Yet digital payment initiatives in emerging economies continue to face uneven adoption and frequent implementation failures (Nalluri and Chen, 2024). These persistent shortcomings suggest that policy and industry responses often address visible symptoms, such as slow uptake, rather than the structural conditions that produce them, including limited trust, weak institutions, or uncertain regulatory environments. This motivates the need for a diagnostic tool that can reveal the deeper sources of failure across the digital payment ecosystem.

Despite extensive research, the literature lacks an integrated typology that links the structural location of a barrier within the Payment Technology Stack to its causal character from a socio-technical perspective. Existing studies typically classify constraints either as technical issues or as social and institutional challenges, but rarely explain how these forces interact across layers of the system (Murinde et al. 2022; Dani et al. 2005; Tay et al. 2022). This fragmentation limits the ability of scholars and decision makers to interpret the systemic nature of digital payment failures and to design interventions that target root causes.

To address this gap, the review proposes a structured way to link where a barrier sits within the Payment Technology Stack to the socio-technical forces that generate it. This approach provides a clearer diagnostic foundation for analysing digital payment failures and supports more targeted research and policy responses.

1.3 Analytical Framework: The Payment Technology Stack and Socio-technical Lens

The operational structure of digital payment systems is architecturally defined by the Digital Stack (Dani et al. 2005), a three-tiered model used to classify the systemic location of components and failures. This architecture provides the primary vertical axis for our analysis:

- **Foundational Infrastructure Layer:** The bedrock, comprising non-negotiable physical utilities (e.g., electricity, reliable ICT networks) and mandatory institutional mechanisms (e.g., RTGS (Real-Time Gross Settlement) and ACH (Automated Clearing House), and secure digital identification) that ensure systemic stability and compliance.

- **Service Middleware Layer:** The transactional nexus where value transfer is orchestrated. This layer manages clearing, settlement, liquidity provision, and, critically, enforces the regulatory frameworks and interoperability standards required for diverse financial and non-bank entities to transact seamlessly.

- **User-Facing Application Layer:** The point of engagement, including mobile wallets, POS terminals, and web portals, whose design and perceived utility dictate end-user adoption across both B2C and B2B segments.

However, a purely technical, architectural view is demonstrably insufficient, particularly in the complex operating environment of developing markets (DMs). DMs face compounding barriers, including infrastructure deficits, high informal economy participation, deeply entrenched cash reliance, and significant heterogeneity in digital literacy and trust, that are rooted in the interaction between technology and context (Albuainain and Ashby, 2025) . Therefore, the barriers to successful deployment are rarely purely technical; they are suggestive of deeper organisational and relational deficiencies. We assert that digital payment systems in DMs are more accurately conceptualised as a Socio-Technical System (STS), where technical components and socio-organisational elements are tightly coupled and interdependent.

Socio-technical systems thinking emphasises that outcomes in technology-enabled environments are shaped by ongoing interactions among people, organisational routines, cultural norms, institutional arrangements and the technical artefacts that bind these together. In digital payment ecosystems, these interactions are especially visible because a failure in any one domain can produce cascading effects across the entire arrangement, from user experience to backend infrastructure. Prior work highlights that socio-technical misalignments often explain why technologically functional systems still underperform in practice, particularly in settings where institutional capacity and digital capability are uneven (Ahlborg et al. 2019; Shojaei and Burgess 2022). The six socio-technical domains used in this review, people, processes, culture, goals, technology and infrastructure, align with established models of socio-technical design and provide a coherent structure for examining the systemic nature of digital payment barriers.

The Digital Stack clarifies where problems occur in payment architectures, but it treats most failures as technical. The STS perspective explains what kind of socio-technical forces shape outcomes, but it is largely agnostic about their position within payment infrastructures (Ahlborg et al. 2019). In this review, we therefore combine the two into a classification matrix that uses the three layers of the Payment Technology Stack as its vertical dimension and the core STS determinants of people, process, culture, goals, technology and infrastructure as its horizontal dimension. This merged framework allows barriers to be located both by their structural position in the payment system and by their dominant socio-technical character, providing a more complete diagnostic tool than either lens alone.

1.4 Research Questions and Thesis Outline

The need for such a diagnostic tool shapes the guiding research questions:

RQ1. What factors hinder the adoption and effective use of digital payment systems in emerging markets?

RQ2. How can these barriers be categorised within a merged socio-technical and Payment Technology Stack Matrix to identify where constraints originate and where interventions are most needed?

The remainder of this paper is structured as follows. The next section explains the research design and methodology of the systematic literature review, including data sources, screening criteria and the analytical approach used to synthesise findings. The subsequent section presents the core results, organising the evidence on digital payment barriers according to the socio-technical determinants and the layers of the payment ecosystem. The discussion section then interprets these findings from a system perspective, examining how different categories of barriers interact and what this implies for digital payment strategies in emerging markets. The final section concludes by summarising the main contributions, noting limitations and outlining directions for future research.

2. Methods and Research Design

2.1 Overview of the SLR Approach

This study employed a systematic literature review to examine barriers to digital payment adoption in developing economies. A systematic review provides a structured and transparent process for identifying and synthesising research relevant to a defined question, using explicit methods that minimise bias and enhance reproducibility (Tranfield et al. 2003). In line with Preferred Reporting Items for Systematic Reviews and Meta Analyses (PRISMA) 2020 standards, this procedure offered a strong fit for capturing the wide-ranging and cross-disciplinary evidence base on digital payment barriers in developing economies. It enabled the comprehensive consolidation of empirical evidence, the identification of recurrent themes and the detection of gaps in current knowledge (Randles and Finnegan 2023). The review offers a rigorous and replicable synthesis of the socio-technical constraints that influence adoption outcomes and directly supports the thematic analysis and framework development that follow.

2.2 Search Strategy

The first stage of the review involved reading a small set of preliminary studies to identify the central concepts and develop an initial pool of keywords. Once this preliminary list was created, the terms were refined with support from CHATGPT 4 on 7 August 2025, which was used to expand the set of possible synonyms and related expressions (OpenAI, 2025). This refinement produced a comprehensive group of search terms, from which the final search string was then constructed as follows:

Complete search string used in Scopus and Web of Science

(TITLE ABS KEY ((FinTech OR "financial technology" OR "digital finance" OR "financial innovation" OR "digital banking" OR "mobile money" OR "mobile payment*" OR "digital wallet*" OR "QR code payment*" OR NFC OR USSD OR "contactless payment*" OR "instant payment*" OR "peer to peer payment*" OR UPI OR Raast OR Mojaloop OR Ripple OR SWIFT))

AND TITLE ABS KEY ("infrastructure gap*" OR "digital divide" OR "regulatory barrier*" OR "policy vacuum" OR "institutional void*" OR "scaling barrier*" OR "adoption challenge*" OR "implementation barrier*" OR "growth constraint*")

AND TITLE ABS KEY ("developing countr*" OR "emerging econom*" OR "low income countr*" OR “LMIC” OR "global south" OR "South Asia" OR "Sub Saharan Africa" OR MENA OR "Latin America" OR Pakistan OR India OR Kenya OR Nigeria OR Egypt OR Vietnam)

This query was applied in Scopus and Web of Science, as they are selected for their comprehensive indexing of peer-reviewed journals in disciplines relevant to the study (Pranckutė 2021). To capture studies not indexed in these commercial databases, the same string was run in Google Scholar, which broadened coverage to include certain forms of grey literature.

The search was conducted in August 2025 and updated in October 2025. The search yielded a total of 563 records, with 342 retrieved from Scopus and 221 from Web of Science. A start date of 2010 was chosen intentionally to capture early literature following the initial success of M-Pesa and similar foundational mobile payment deployments. Despite this wide window, no studies before 2010 appeared in the results, reflecting the relatively recent emergence of FinTech scholarship in developing economies.

2.3 Screening and Selection

After 563 articles were retrieved, screening followed PRISMA principles to ensure accountability and consistency. All references were imported into Rayyan AI, a platform designed for systematic reviews. Rayyan removed overlapping records through automated deduplication (Ouzzani et al. 2016). It also highlighted key terms during semi-automated screening and suggested possible inclusions or exclusions without replacing the researcher’s judgement. Its tagging system allowed studies to be marked as include, exclude, or maybe, which improved clarity and pace. Rayyan never made decisions on its own; it only accelerated the process while the researcher kept full methodological control. The original search retrieved 563 records. After removing duplicates, 471 unique items were screened at the title and abstract levels using predefined inclusion and exclusion criteria, which are mentioned below:

Inclusion criteria

Studies were included if they:

- were peer-reviewed journal articles published between 2010 and 2025
- focused on FinTech, digital payments or digital financial services
- examined barriers, constraints or challenges to adoption, implementation or scaling
- related to at least one developing or emerging economy
- employed empirical methods or conceptually grounded analysis
- were published in English
- had a full text available for review

These criteria ensured that only academically robust, contextually relevant studies were synthesised.

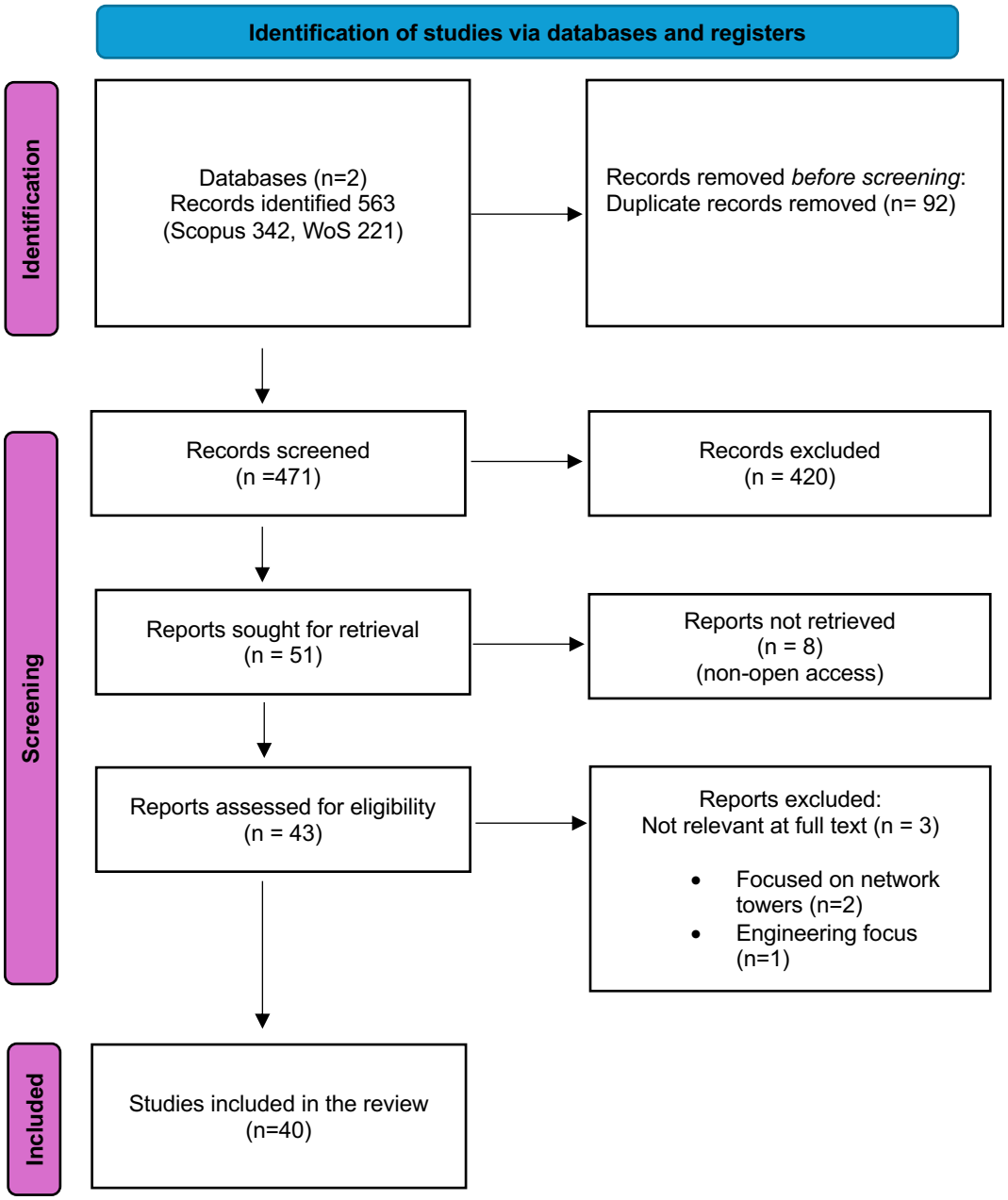
Exclusion criteria

Studies were excluded if they:

- were conference papers, editorials, theses or non-scholarly materials
- focused exclusively on advanced economies
- addressed banking or technology topics unrelated to digital finance
- lacked empirical or conceptual discussion of barriers
- were not published in English or lacked an accessible full text
- duplicated an already included study

Following title and abstract screening, the remaining studies moved to full-text assessment. Out of 563 studies, only **40** publications met all inclusion criteria and formed the empirical corpus for the thematic synthesis. A PRISMA-style flow diagram summarises the screening process below.

Figure 1: PRISMA-Style flow diagram



2.4 Data Extraction and Coding

The data extraction and coding procedures followed PRISMA standards, which supported transparent reporting and procedural consistency throughout the review. The process began with the creation of a structured extraction tool, referred to as the classification sheet. This tool ensured that all studies were captured in a uniform way, including bibliographic details, geographical and sectoral context,

methodological features, theoretical framing and the full set of barriers reported by each author. This step created a coherent evidentiary base and reduced variation caused by inconsistent reporting across the primary studies.

Following this, all 40 studies that met the inclusion criteria were imported into NVivo 15 (QSR International) to facilitate systematic qualitative analysis. NVivo provided a controlled environment for the organisation, interrogation and synthesis of qualitative data, allowing barrier-related text segments to be coded consistently and retrieved efficiently for comparative analysis (Wong 2008; Zamawe 2015). The analytic strategy followed a hybrid approach that integrated inductive human coding with a secondary AI-assisted layer designed to enhance interpretive robustness.

Manual Coding in NVivo

The first stage of analysis involved inductive, manual coding carried out by the researcher. Each full text was read closely, with particular attention to the findings, analysis and discussion sections where barriers are usually described in detail. Coding began with an open coding approach (Braun and Clarke 2006), where first-order labels were applied to any part of the text that identified a challenge, constraint or impediment related to digital payments or FinTech use. The wording used by the original authors was kept as much as possible to preserve the meaning of the primary studies and avoid premature interpretation.

NVivo's hierarchical structure allowed the researcher to group emerging codes into early clusters as patterns began to form. Alongside this, analytic memos were used to record decisions, note uncertainties and capture evolving ideas during the coding process. This manual stage produced a rich set of first-order codes that reflected the full range of barrier descriptions reported across the studies.

AI Assisted Coding with ChatGPT

To improve the reliability of the analysis and reduce the subjectivity that comes with single researcher coding, ChatGPT (GPT 5) was used as a supplementary interpretive tool (OpenAI, 2025). Each study was processed with structured prompts that asked the model to identify all concepts related to barriers. This produced an independent set of possible first-order codes, creating a comparison point like the triangulation often used with two human coders. The AI-generated outputs were then compared with the manual codes. Areas of agreement increased confidence in the stability of the coding structure.

When ChatGPT surfaced barrier concepts that had not been coded manually, the researcher returned to the original text to check whether there was clear evidence for them. Only concepts supported directly by the primary study were added, ensuring that interpretation remained grounded in the source material. This triangulated approach provided an extra layer of confirmation and occasionally prompted deeper analytical reflection, while keeping all final analytic decisions firmly with the researcher.

Integration and Development of the Coding Structure

The integration of human and AI-informed codes resulted in a consolidated coding structure organised hierarchically within NVivo. Codes were compared iteratively, merged where appropriate and grouped into emergent second-order categories. NVivo's query functions supported this process by verifying that each category was underpinned by multiple primary studies, thereby ensuring analytic stability and cross-contextual validity. The resulting structure constituted a comprehensive, well-evidenced representation of the barrier landscape described across the literature.

2.5 Thematic Synthesis

A thematic synthesis approach was used to develop increasingly abstract interpretive insights from the coded data (Braun and Clarke 2006). This analytic strategy aligns with established qualitative synthesis methodologies and progresses through layered abstraction from first-order codes to higher-level themes. The synthesis remained inductive throughout, allowing concepts to emerge from the evidence base rather than imposing predetermined classifications.

First Order Codes

First-order codes represented the foundational layer of synthesis. These codes captured the explicit barrier statements contained in the primary studies, including issues such as infrastructural unreliability, user trust deficits, operational inefficiencies, regulatory ambiguity or institutional capability constraints. They served as the empirical building blocks from which broader conceptual structures were derived.

Second Order Categories

Through a process of constant comparison, conceptually similar first-order codes were consolidated into second-order categories. These categories represent more abstract descriptions of recurring issues rather than specific statements. For instance, numerous codes about weak network performance, localised signal gaps or frequent outages were synthesised into an infrastructure and access limitations category. Similarly, codes related to awareness deficits, digital skills gaps and trust challenges were combined into categories representing user-related constraints. While ChatGPT's grouping suggestions were occasionally informative, category formation remained anchored in the empirical dataset and interpretive decisions of the researcher.

Higher Level Themes

The second-order categories were then synthesised into higher-level themes that captured the major domains of barriers across studies. These themes reflect multi-dimensional structures such as technological and infrastructural barriers, user and cultural barriers, organisational and process-related barriers and institutional and regulatory barriers. Each theme was refined iteratively to ensure internal coherence and distinctiveness from other themes. Only themes supported by multiple studies and diverse contexts were retained.

2.5 Construction of the Classification Matrix

After the thematic synthesis had produced 41 first-order barriers and 8 higher-level themes, these outputs were organised using the integrated STS and Payment Technology Stack framework introduced in section 1.3. Each barrier was assigned to one cell of a three-by-six Classification Matrix according to two criteria.

First, a layer criterion captured the point in the payment system where the barrier primarily manifests in practice, distinguishing between the user layer, the middleware layer and the infrastructure layer. For example, confusing onboarding procedures and language mismatches were placed in the user layer, while fragmented payment rails and legacy core banking systems were placed in the middleware and infrastructure layers, respectively.

Second, a socio-technical criterion captured the dominant mechanism through which the barrier operates, classifying it under people, process, culture, goals, technology or infrastructure. Thus, low digital literacy and reliance on others were coded in the people row, weak dispute handling processes in the process row, preference for cash and tax avoidance norms in the culture row, and connectivity gaps or device costs in the technology and infrastructure rows.

Several barriers could plausibly relate to more than one cell. In such cases, the barrier located in the cell best reflects its primary origin, while its cross-cutting effects were discussed in the narrative interpretation of the matrix. All placements were grounded in the detailed NVivo coding structure and were checked against the original study excerpts to ensure fidelity to the primary evidence. The resulting Classification Matrix, presented in Table 8, provides the basis for answering RQ2 by showing how barriers are distributed across layers and socio-technical dimensions.

3. Results

This section outlines the descriptive profile of the forty studies included in the review. In line with established SLR practice within FinTech and digital payment research, the metadata are synthesised across five dimensions: geographical focus, study type and methodological approach, FinTech domain, primary analytical level and publication venues. A detailed table of study characteristics is presented in the appendix.

Table 1: List of Studies

Authors	Title
(Agarwal and Assenova 2023)	Mobile Money as a Stepping Stone to Financial Inclusion: How Digital Multisided Platforms Fill Institutional Voids
(Agrawal et al. 2025)	Challenges in the adoption of FinTech by women in rural areas of India using interpretive structural analysis
(Aidonojie et al. 2023)	The Legal Issues Concerning the Operation of Fin Tech in Nigeria
(Ajouz et al. 2023)	Navigating the Uncharted: The Shaping of FinTech Ecosystems in Emerging Markets
(Ali et al. 2019)	An integrated framework for mobile payment in Pakistan: drivers, barriers, and facilitators of usage behaviour
(Bakhshi et al. 2024)	Barriers in adoption of FinTech by street vendors and hawkers in India using interpretive structural modelling
(Braido et al. 2021)	Facilitators and Barriers faced by Mobile Payment FinTech's in the Brazilian Context
(Buckley and Webster 2016)	FinTech in Developing Countries: Charting New Customer Journeys
(Butt and Khan 2019)	FinTech in Pakistan: a qualitative study of bank strategic planning
(Cele 2023)	Determining customer acceptance of digital only banks in South Africa: UTUAT extension
(Ehret and Olaniyan 2023)	Banking the unbanked. Constitutive rules and the institutionalisation of mobile payment systems in Nigeria
(Habash 2024)	Determinants of FinTech Service Utilization and Access Factors: Case of Palestine
(Hassan 2025)	Barriers to e banking adoption in Egypt: an expert based interpretive structural modelling analysis
(Higgo and Botha 2025)	Digital Innovation Management in Developing Economies
(Hurani et al. 2024)	FinTech Implementation Challenges in the Palestinian Banking Sector
(Imam et al. 2022)	Opportunities and Barriers for FinTech in SAARC and ASEAN Countries
(Irianto and Chanvarasuth 2025)	Drivers and Barriers of Mobile Payment Adoption among MSMEs: Insights from Indonesia
09/12/2025 11:56:00	A Secure Future for UPI: Identifying Key Drivers and Overcoming Challenges
(Kabengele and Hahn 2021)	Institutional and firm level factors for mobile money adoption in emerging markets
(Kuriakose and Sajoy 2023)	Strategies and Challenges of Unified Payment Interface
(Loke et al. 2025)	Digital financial services adoption: the role of trust and government intervention as mediators
(Mohd and Razali 2024)	Navigating Obstacles Encountered by FinTech Startups: An in-depth systematic literature review
(Mukhopadhyay and Upadhyay 2022)	Institutional intervention in technology innovation: the struggle to increase mobile payment adoption
(Nalluri and Chen 2024b)	Modelling the FinTech adoption barriers in the context of emerging economies: an integrated fuzzy hybrid approach
(Noreen et al. 2021)	The impact of perceived risk and trust on adoption of mobile money services: an empirical study in Pakistan

Authors	Title
(P and C 2019)	Challenges in adoption of new technologies in the banking sector
(Pal et al. 2020)	Contextual facilitators and barriers influencing the continued use of mobile payment services
(Panda et al. 2022)	Does the cashless transaction work? An analysis of policy challenges in an emerging economy
(Pareek and Maidullah 2025)	Challenges and opportunities in the adoption of FinTech in emerging markets
(Payandeh and Babaei 2025)	Policy feedback dynamics in FinTech ecosystems: navigating vicious and virtuous cycles
(Priya and Anusha 2019)	FinTech issues and challenges in India
(Putrevu and Mertzanis 2023)	The adoption of digital payments in emerging economies: challenges and policy responses
(Rana et al. 2019)	Key challenges to digital financial services in emerging economies: the Indian context
(Rana et al. 2020)	Assessing challenges to mobile wallet usage in India: an interpretive structural modelling approach
(Shala and Perri 2022)	Regulatory barriers for FinTech companies in Central and Eastern Europe
(Singh et al. 2025)	Revolutionizing Digital Banking: Determinants and Barriers of Neo Banking Adoption
(Sanjay Sinha et al. 2018)	FinTech and the demand side challenge in financial inclusion
(Sugeng and Aidy 2025)	Regulating Digital Finance for SME Growth: Lessons from Thailand and Malaysia
(Suryono et al. 2020)	Challenges and trends of financial technology: a systematic literature review
(Widayani et al. 2022)	Barriers to digital payment adoption among micro, small and medium enterprises

3.1 Geographical context of the studies

Table 2 reports the geographical distribution of the included studies. India is the most frequently studied context, accounting for 14 of the 40 articles. Indonesia appears in 5 studies, followed by Pakistan with 4, and South Africa and Nigeria with 3 each. A further 5 studies analyse emerging markets in general rather than a single country. The remaining contributions focus on Malaysia (2 studies) and Brazil, Egypt, Iran, Kosovo and Palestine (1 study each).

Overall, South Asia and large emerging economies dominate the evidence base, while smaller developing countries and low-income regions appear far less often. This concentration has implications for the transferability of findings, as much of what is known about digital payment barriers is derived from a relatively small cluster of economies with comparatively advanced infrastructures and policy attention.

Table 2: Geographical context

Region / Country Focus	Count
India (Specific)	14
Indonesia	5
Pakistan	4
South Africa	3
Nigeria	3
Emerging Markets (General)	5
Malaysia	2
Brazil	1
Egypt	1
Iran	1
Kosovo	1
Palestine	1
Total	**40**

3.2 Study type and methodological approaches

Table 3 shows the methodological profile of the 40 studies. Quantitative designs dominate the corpus, with 26 studies using survey-based approaches and related modelling techniques. Qualitative designs appear in 13 studies, including case studies, interviews and interpretive structural modelling. Only 1 study uses a mixed methods design.

When grouped by primary methodological family, 25 studies (62.5%) employ technology adoption models such as TAM, UTAUT and related intention-based frameworks. Socio-institutional and ecosystem-oriented approaches, including institutional theory, interpretive structural modelling and policy or governance frameworks, are used in 11 studies (27.5%). The remaining 4 articles (10.0%) are best classified as case-based, legal or narrative review contributions. This distribution mirrors the wider FinTech literature and indicates that individual-level adoption theories still dominate explanations of digital payment barriers, while system and governance-oriented perspectives remain comparatively underrepresented.

Table 3: Methodological Approaches

Category	Count
Study Type: Quantitative (Surveys, SEM, PLS, fsQCA)	26
Study Type: Qualitative (ISM, Interviews, Case Study, Review)	13
Study Type: Mixed Methods	1
Primary Methodology Used:	
Technology Adoption Models (UTAUT/TAM/IRT)	25
Socio-Institutional/Ecosystem Models (ISM, Institutional Theory, GFD/FOI)	11
Case Study / Legal / Review	4
Total	**40**

3.3 Technological Focus

The technological focus of the included studies is presented in Table 4. Mobile payment and wallet services are by far the most prominent domain, examined in 25 studies (62.5 %). A further 12 studies (30.0 %) address FinTech adoption or digital financial services in a more general sense, often treating digital payments as one element within broader ecosystems. Only 3 studies (7.5 %) concentrate specifically on mobile or electronic banking.

These figures indicate that research on barriers in developing economies is strongly anchored in the mobile payment and wallet space, which reflects the central role of these technologies in current financial inclusion agendas. At the same time, there is relatively limited evidence on barriers linked to other payment technologies and adjacent services, such as merchant acquiring, remittance platforms or integrated bank-based systems.

Table 4: Technological Focus

FinTech Focus	Count
Mobile Payment/Wallet (General/UPI/M-payment)	25
FinTech Adoption/Ecosystem (General/DFS)	12
Mobile Banking/E-Banking	3
Total	**40**

3.4 Primary level of analysis

Table 5 classifies the studies according to their main level of analysis. The majority, 27 articles (67.5 %), adopt a micro-level focus on individual users. These studies typically model behavioural intentions and usage through constructs such as perceived usefulness, ease of use, trust, perceived risk or social influence. Only 13 studies (32.5 %) take a meso or macro perspective, examining organisational strategies, market structures, regulatory arrangements, infrastructure provision or ecosystem voids.

The imbalance between micro and system-level work is important for interpreting reported barriers. Much of the existing evidence foregrounds attitudinal and psychological factors, while structural constraints located in infrastructures, institutions and market design are addressed less frequently and often only indirectly. This supports the need for the socio-technical and stack-based perspective developed in the later analytical sections of this review.

Table 5 :Level of Analysis

Level of Analysis	Definition	Count
Micro-level	User behaviour, psychological factors (Trust, Risk, Ease of Use, etc.)	27
Meso/System-level	Organizational, Market Structure, Policy, Infrastructure, Ecosystem Voids	13
Total		**40**

3.5 Journals and publication venues

The dispersion of the 40 studies across journals is shown in Table 6. The most common outlets are Journal of Financial Services Marketing (7 articles) and Digital Policy, Regulation and Governance (5 articles). Journal of Business Research accounts for 4 studies, while International Journal of Information Management and its companion Data Insights journal contribute 3 articles. Journal of Risk and Financial Management also publishes 3 studies, and Technology Analysis and Strategic Management publishes 2. Single contributions appear in outlets such as Organisation Science, Technological Forecasting and Social Change, Brazilian Business Review and SA Journal of Information Management, among others, with the remaining 12 studies scattered across a wide set of journals.

This spread confirms the multidisciplinary nature of digital payment and FinTech barrier research, spanning information systems, marketing, finance, development and policy journals. It also suggests that relevant evidence is fragmented across fields, reinforcing the value of a systematic review that consolidates findings from these diverse disciplinary sources.

Table 6: Publication Venues

Journal	Count
Journal of Financial Services Marketing	7
Journal of Risk and Financial Management	4
Digital Policy Regulation and Governance	4
Journal of Theoretical and Applied Electronic Commerce Research	2
Organization Science	1
Technology Analysis and Strategic Management	1
Jurnal Media Hukum	1
Cuadernos de Economia	1
Business Theory and Practice	1

Journal	Count
Brazilian Business Review	1
Journal of Financial Transformation	1
Independent Journal of Management and Production	1
SA Journal of Information Management	1
Journal of Business Research	1
Research Square	1
South African Journal of Industrial Engineering	1
Technological Forecasting and Social Change	1
Journal of Telecommunications and the Digital Economy	1
International Journal of Accounting and Economics Studies	1
Journal of Islamic Marketing	1
International Journal of Information Management Data Insights	1
Information Technology for Development	1
International Journal of Bank Marketing	1
International Journal of Recent Technology and Engineering	1
IOSR Journal of Business and Management	1
Information Technology and People	1
International Journal of Information Management	1

3.6 Study characteristics

To complement the aggregate statistics above, an appendix table provides a study-by-study overview. For each of the 40 articles, it records the citation, country or region, specific FinTech domain, research design and data type, sample size or data source, and a concise summary of the key barrier-related findings. This table supports transparency regarding which contexts and methods underpin the synthesis and allows readers to inspect the distribution of evidence in greater detail.

3.7 Thematic Analysis

After metadata analysis, Thematic coding of the 40 studies produced a detailed set of barrier statements that directly address RQ1 on what factors hinder the adoption and effective use of digital payments in emerging markets. In the first stage of analysis, open coding generated 41 distinct first-order barriers**.** These barriers retain the wording and conceptual meaning of the primary studies and are grouped for reporting purposes into broad categories such as user literacy and awareness, social and cultural influences, trust and risk perceptions, consumer protection, infrastructure and connectivity, regulation and compliance, market structure, economic and cost constraints, and organisational capability.

Table 7 presents this catalogue of 41 barriers in full, together with concise descriptions. It provides a transparent view of the empirical material that underpins the later stages of the analysis and shows the breadth of challenges documented in the literature. In the second stage, these 41 first-order barriers were iteratively compared and clustered into a smaller set of more abstract concepts. Through this process, the review identified 8 higher-level themes that capture how barriers tend to co-occur and interact across studies. These themes are not simply a relabelling of individual barriers but represent broader patterns that cut across countries, technologies and stakeholder groups.

Table 7: List of Barriers Identified

Barrier	Description	Key citations
Limited user literacy	Many individuals lack the digital skills needed to operate payment apps or understand their functions.	(Agarwal and Assenova 2024; Ali et al. 2024; Reddy and Rakesh 2019)
Low financial literacy	Users struggle with financial concepts which reduces confidence in digital services.	(Agarwal and Assenova 2024; Noreen et al. 2021; Sinha et al. 2018)

Barrier	Description	Key citations
Low awareness of Digital payments benefits	People are unfamiliar with the advantages of digital payments.	(Agrawal et al. 2025; Irianto and Chanvarasuth 2025)
Dependence on others for digital tasks	Less literate users rely on intermediaries to complete transactions.	(Agrawal et al. 2025; Agarwal and Assenova 2024)
Cash dominant culture	Heavy reliance on cash creates behavioural resistance.	(Panda et al. 2022; Rana et al. 2019)
Social norms discouraging digital use	Community practices shape reluctance to use digital payments.	(Agrawal et al. 2025; Cele 2023)
Gender based access gaps	Women have reduced device access and autonomy.	(Agrawal et al. 2025; Agarwal and Assenova 2024)
Rural demographic disadvantage	Remote users have lower exposure to digital finance.	(Agarwal and Assenova 2024; Kabengele and Hahn 2021)
Religious concerns	Users avoid Digital payments perceived as conflicting with beliefs.	(Aidonojie et al. 2023)
Low trust in providers	Users doubt FinTech firms' ability to protect data or funds.	(Loke et al. 2025; Mukhopadhyay and Upadhyay 2022)
Fear of fraud	Concerns over scams and identity theft deter digital use.	(Hassan 2024; Noreen et al. 2021)
Cybersecurity vulnerabilities	Perceived weak protection against hacking reduces confidence.	(Higgo and Botha 2025; Loke et al. 2025)
Data privacy concerns	Users worry about access to and misuse of their information.	(Loke et al. 2025; Hassan 2024)
Negative media narratives	Reports of fraud or failures increase risk perceptions.	(Suryono et al. 2020)
Weak dispute resolution	Failed transactions cannot be resolved easily.	(Hassan 2024; Panda et al. 2022)
Limited refund mechanisms	Slow refund processes increase financial risk.	(Rana et al. 2020; Panda et al. 2022)
Poor customer support	Difficulties getting help reduce user trust.	(Butt and Khan 2019; Mukhopadhyay and Upadhyay 2022)
Ambiguous liability	Unclear responsibility for fraud or error deters use.	(Aidonojie et al. 2023; Hassan 2024)
Poor network connectivity	Weak mobile or internet signals disrupt payments.	(Ali et al. 2024; Kabengele and Hahn 2021)
Power supply instability	Outages prevent transactions and device charging.	(Kabengele and Hahn 2021)
Low smartphone penetration	Many households lack smartphones capable of running apps.	(Agarwal and Assenova 2024)
Limited digital access points	Lack of agents or branches restricts practical usability.	(Agarwal and Assenova 2024; Widayani et al. 2022)
Device constraints	Basic phones limit Digital payments functionality.	(Agarwal and Assenova 2024)
Ambiguous regulatory environment	Unclear or conflicting rules slow Digital payments expansion.	(Aidonojie et al. 2023; Payandeh and Babaei 2025)
Heavy compliance requirements	Strict KYC and documentation exclude unregistered users.	(Kabengele and Hahn 2021; Agarwal and Assenova 2024)
Licensing and capital barriers	High costs limit market entry for FinTech startups.	(Payandeh and Babaei 2025; Nurul Ain Mohd and Razali 2024)
Slow policy response	Regulations lag technological innovation.	(Aidonojie et al. 2023; Payandeh and Babaei 2025)
Fragmented payment landscape	Poor interoperability reduces seamless transfers.	(Kuriakose and Sajoy 2023; Putrevu and Mertzanis 2024)
Low merchant acceptance	Merchants prefer cash or lack digital terminals.	(Panda et al. 2022; Rana et al. 2019)
Weak agent networks	Sparse or unreliable agents undermine cash in cash out.	(Agarwal and Assenova 2024; Widayani et al. 2022)
Incumbent resistance	Banks and telecoms may block integration or access.	(Mukhopadhyay and Upadhyay 2022; Ajouz et al. 2023)
Poor industry collaboration	Weak partnerships slow ecosystem development.	(Ajouz et al. 2023; Nurul Ain Mohd and Razali 2024)
High transaction fees	Fees make digital payments unattractive for low-income users.	(Panda et al. 2022; Sinha et al. 2018)
High cost of devices	Smartphones remain unaffordable for many users.	(Agarwal and Assenova 2024)

Barrier	Description	Key citations
Price sensitive behaviour	Users revert to cash when digital fees increase.	(Panda et al. 2022)
Income volatility	Irregular earnings discourage maintaining digital balances.	(Sinha et al. 2018)
Insufficient funding for providers	Startups lack capital to scale and improve services.	(Nurul Ain Mohd and Razali 2024; Payandeh and Babaei 2025)
Shortage of skilled talent	Providers lack technical, cybersecurity and compliance expertise.	(Ajouz et al. 2023)
Legacy system limitations	Outdated systems hinder integration of Digital payments.	(Mukhopadhyay and Upadhyay 2022)
Organisational resistance to change	Institutions are slow to adopt digital models.	(Mukhopadhyay and Upadhyay 2022)
Weak innovation support structures	Limited incubators and accelerators restrict growth.	(Nurul Ain Mohd and Razali 2024; Ajouz et al. 2023)

Themes

The analysis moves from detailed barrier statements to a more abstract explanation of the underlying patterns observed across the literature. This progression is reflected in Table 8, which connects each first-order barrier to an intermediate second-order category and then to one of the eight overarching themes. The subsections that follow discuss each theme in depth and draw on illustrative evidence from the reviewed studies, thereby presenting a more integrated and synthetic response to RQ1.

Table 8: Theme Development

Aggregate Barrier Theme (Final Level)	Second-Order Code (Conceptual Category from NVivo Heading)	Representative First-Order Codes (Specific Barrier Statements)
Limited User Literacy and Awareness	"Literacy, awareness and knowledge constraints"	Lack of information or awareness lack of literacy, low digital literacy, low financial literacy.
Economic and Cost Constraints / Service Design and Value	"Service design and value proposition limitations"	Perceived High Cost, expensive to use, high cost of operations, Lack of Added Value, Poor usability and complexity, Bad User Interface.
Trust, Security and Risk Perceptions	"Trust, security and perceived risk"	Fraud & Cyber Security, Cyber Security, Data Privacy Challenge, Lack of Trust, Media and Image related risk.
Social and Cultural Influences	"Social norms, culture and demographic barriers"	Cash Culture, society norms, gender disparity, Religious Factors, sharia compliance, Avoid Taxation.
Infrastructure and Connectivity Limitations	"Infrastructure & Access Limitations"	Poor internet connectivity, poor network, Poor power supply, Lack of smart phone penetration, Lack of Bank Branches.
Market Fragmentation and Ecosystem Challenges	"Ecosystem coordination and interoperability challenges"	Lack of interoperability, competition, lack of partnerships, stakeholder collaboration.

Aggregate Barrier Theme (Final Level)	Second-Order Code (Conceptual Category from NVivo Heading)	Representative First-Order Codes (Specific Barrier Statements)
Regulatory and Compliance Barriers	"Legal, regulations & Compliance"	Legal Challenges, KYC, Transaction limit, Govt Support, lack of accountability of firms.
Organisational and Capability Gaps in Providers	"Organisational readiness and capability gaps"	HR Issues, Financing Issues for Firms, organizational resistance, lack of institutional flexibility.

Limited User Literacy and Awareness

A prominent barrier reported across the literature is the limited level of user literacy and awareness surrounding digital payment systems. Studies show that many individuals cannot understand FinTech interfaces, interpret instructions, or confidently use digital financial tools, particularly in underserved regions where exposure to technology is minimal (Agarwal and Assenova 2024; Aidonojie et al 2023; Ajouz et al 2023). This lack of understanding contributes directly to hesitation, uncertainty, and perceived risk, which discourages users from adopting even basic mobile payment functions (Ali et al 2024; Butt and Khan 2019). Research that examines street vendors and microentrepreneurs highlights that low literacy is a critical driver of resistance, as users struggle to follow digital procedures or evaluate potential benefits and drawbacks of FinTech services (Bakhshi et al 2024; Agarwal et al 2025). Similarly, several studies identify insufficient knowledge and limited awareness of digital financial services as central impediments, noting that users often lack clarity about transaction processes, security practices, and the purpose of digital records (Hassan 2024; Aidonojie et al 2023). These gaps force many users to depend on others to complete routine digital transactions, undermining autonomy and reinforcing their reluctance to shift from familiar cash-based practices (Ajouz et al 2023; Ali et al 2024).

Collectively, these studies converge on the view that user readiness remains constrained by deep and persistent literacy limitations. Without targeted investment in digital and financial education, the adoption of Digital payments will continue to be hindered by foundational capability deficits (Agarwal and Assenova 2024; Bakhshi et al 2024).

Affordability and Economic Constraints

The cost of accessing and using digital financial services remains a significant barrier for many users in developing economies. For low-income populations, the upfront cost of smartphones poses a major hurdle, as internet-enabled devices remain expensive relative to household earnings and replacement costs are often unaffordable when devices fail (Butt and Khan 2019; Priya and Anusha 2019). Even basic handsets and SIM cards can strain limited budgets and restrict the ability of the poorest users to engage with any form of digital finance. Ongoing expenses such as mobile data charges and transaction fees further discourage adoption, as many households limit online activity to essential communications to avoid high data costs (Pal et al 2020; Cele 2023). For instance, a study noted that while lower fees can significantly encourage people to use mobile wallets or online transfers, conversely, *"*high fees can be a barrier to entry for consumers, especially in emerging markets*"*. When digital transactions incur additional charges, users often return to cash because it is viewed as more economical, especially for small-value payments where fees reduce the overall benefit of using digital channels (Sinha et al 2018; Singh et al 2025). Evidence from multiple studies confirms that high transaction fees are widely

regarded as a direct barrier to the use of digital payments among cost-sensitive consumers (P and C 2019; Imam et al 2022).

Beyond direct costs, the absence of clear financial incentives can also restrict uptake. Many low-income individuals work with very limited disposable income, meaning digital services must deliver noticeable savings or tangible rewards to justify shifting from cash (Payandeh and Babaei 2025; Cele 2023). Poverty and irregular incomes further limit adoption because users may prioritise essential needs over maintaining balances in mobile wallets, leading to dormant accounts or reluctance to keep funds in digital form where they may feel less accessible (Priya and Anusha 2019; Sinha et al 2018). Concerns about possible hidden charges or strict account conditions, often associated with formal financial institutions, can reinforce hesitation among new users. Broader economic pressures, such as inflation or currency instability, also shape user behaviour by encouraging a preference for cash-based coping strategies during periods of uncertainty (Pal et al 2020; Butt and Khan 2019). Overall, ensuring that digital payments are genuinely affordable and clearly cost-effective is vital, as without targeted measures to reduce device and transaction costs, affordability constraints will continue to limit adoption among financially vulnerable groups.

Trust, Security and Risk Perceptions

Issues of trust and perceived risk constitute a major barrier to Digital payments adoption in developing economies. Numerous studies show that users often lack confidence in digital finance providers, particularly newer non-bank FinTech firms, due to concerns about the safety and reliability of their services (Cele 2023; Higgo and Botha 2025). This distrust is closely linked to anxieties about fraud, cybercrime, and system vulnerabilities, with users fearing that money or personal data could be stolen through scams, hacking, or identity misuse (Hurani et al 2024; Imam et al 2022). These concerns are intensified in contexts where cybersecurity protections and regulatory oversight remain weak, making digital platforms appear more exposed to technical failures and malicious attacks (Ehret and Olaniyan 2023; Putrevu and Mertzanis 2023).

Data privacy concerns further erode user confidence. When consumers are unsure how their financial information is used or doubt that firms can safeguard their data, they become hesitant to adopt or fully engage with online payment applications (Sinha et al 2018; Panda et al 2022). High-profile cases of system outages or account breaches, along with reports circulating in local media, amplify perceptions of risk and reinforce the view that digital finance carries significant dangers (Shala and Perri 2022; Cele 2023). In periods of economic or political uncertainty, such fears become even more pronounced, leading users to adopt highly cautious behaviours and favour cash as the perceived safer option (Hurani et al 2024; Ehret and Olaniyan 2023). Therefore, the combination of low trust in providers, strong perceptions of risk, and fears surrounding privacy and security acts as a substantial constraint on Digital payments uptake. Users who doubt that digital platforms are safe tend to avoid them entirely or restrict their usage to minimal, low-value transactions, slowing the scale and diffusion of digital payments (Imam et al 2022; Putrevu and Mertzanis 2023).

Closely linked to trust are barriers arising from weak consumer protection and limited avenues for recourse when digital transactions fail. Studies highlight that users in developing markets frequently encounter issues such as failed transfers, billing errors, and fraud incidents, yet support systems to resolve these problems remain underdeveloped and inconsistent (Agarwal and Assenova 2024; Rana et al 2019). Many report situations in which money is deducted but not received by the intended party, or where erroneous charges occur without timely refunds or accessible assistance channels (Hurani et al 2024; Braido et al 2020). These negative experiences, even when sporadic, can create enduring scepticism toward digital financial services.

Common pain points documented in the literature include disputed or unauthorised charges that are difficult to contest, slow resolution of failed transactions, and customer service responses that lack clarity or timeliness (Panda et al 2022; Shala and Perri 2022). Some users wait extended periods to

receive refunds or face uncertainty about who bears responsibility in the event of fraud, whether the provider, an intermediary agent, or the user (Payandeh and Babaei 2025; Widayani et al 2022). Such ambiguities leave consumers feeling exposed and unsupported. These deficiencies deter adoption in two ways. First, potential users who learn of unresolved incidents within their communities may avoid digital payments entirely, fearing a lack of protection if problems arise (Braido et al 2020; Rana et al 2019). Second, existing users who face unresolved disputes often revert to cash or informal mechanisms, preferring systems they perceive as more predictable and accountable (Hurani et al 2024; Shala and Perri 2022). Although regulators in some regions have moved toward strengthening dispute resolution frameworks, confidence in these mechanisms remains uneven (Agarwal and Assenova 2024; Payandeh and Babaei 2025).

The evidence indicates that without reliable recourse pathways and robust consumer protection standards, users are understandably hesitant to entrust their finances to digital platforms. Strengthening accountability, transaction transparency, and customer service is therefore essential for building trust and supporting wider Digital payments adoption (Widayani et al 2022; Panda et al 2022).

Social and Cultural Barriers

In addition to literacy challenges, social and cultural dynamics strongly influence patterns of digital payment uptake. Evidence from multiple contexts shows that users maintain a strong preference for cash, grounded in habits, familiarity, and social norms that privilege tangible transactions over digital alternatives (Agarwal et al 2025; Butt and Khan 2019). These norms make digital tools appear less trustworthy or less convenient, reinforcing longstanding behaviours among both consumers and small-scale merchants (Aidonojie et al 2023; Cele 2023). Studies also indicate that resistance to change is common in communities where in-person interactions and paper-based systems have historically structured financial activity. Digital payments are sometimes perceived as impersonal or unreliable, creating psychological distance that weakens uptake (Ajouz et al 2023; Ali et al 2024). Further, low endorsement from peers or community figures perpetuates reluctance, as individuals often look to their networks for behavioural cues before adopting unfamiliar technologies (Butt and Khan 2019; Cele 2023). Together, these findings demonstrate that cultural attachment to cash and scepticism toward new technologies continue to constrain the diffusion of digital payments, even in environments where infrastructure and services are increasingly accessible (Agarwal et al 2025; Ali et al 2024).

Demographic inequalities intersect strongly with cultural constraints to shape patterns of Digital payments adoption in developing economies. Several studies observe that gender-based disparities in access to technology and financial resources hinder the ability of women to participate in digital financial ecosystems, particularly where socio-cultural norms restrict their independent decision making or digital access (Priya and Anusha 2019; Noreen et al 2021). These constraints often result in lower levels of digital capability and reduced confidence in using FinTech tools, reinforcing dependence on family members for digital transactions (Cele 2023; Singh et al 2025).

Rural communities face further intersecting disadvantages. Evidence shows that individuals in remote areas frequently encounter weaker digital infrastructure, limited agent networks, and reduced exposure to formal financial education, all of which push them toward continued reliance on cash or informal systems (Pal et al 2020; Rana et al 2019). Such regional disparities contribute to lower adoption rates among rural women, older populations, and socio-economically marginalised groups, who are often the least targeted by digital inclusion initiatives (Hassan 2024; Widayani et al 2022). Cultural norms and belief systems further reinforce these barriers. Studies note that in communities where traditional practices and personal interactions dominate financial behaviour, digital payment systems are sometimes viewed as impersonal, unfamiliar, or inconsistent with established expectations (Hurani et al 2024; Putrevu and Mertzanis 2023). Religious considerations may also influence uptake, particularly where users question whether financial products align with local religious principles or ethical expectations (Cele 2023; Sinha et al 2018). When FinTech services are perceived as culturally or religiously misaligned, users often avoid them even when technological infrastructure is available.

Taken together, these demographic, social, and cultural factors create a layered set of constraints that reinforce resistance to Digital payments, interacting with limited digital ability and persistent cash-based norms to restrict the reach of digital financial inclusion efforts (Hassan 2024; Rana et al 2019).

Infrastructure and Connectivity Limitations

A foundational barrier to digital payments uptake in developing economies concerns the inadequacy of both digital and physical infrastructure, which limits consistent access to financial services. Studies show that digital payment systems depend heavily on stable connectivity and electricity, yet many regions continue to experience poor network coverage, intermittent internet, and frequent power disruptions that interrupt transactions (Rana et al 2019; Suryono et al 2020). In rural and low-income communities, the reach of FinTech is further restricted by low internet penetration and limited smartphone ownership, meaning large portions of the population cannot get online reliably or do not possess internet-capable devices needed for app-based services (Priya and Anusha 2019; Imam et al 2022). Even when users have mobile phones, these may be basic handsets that support SMS but not app-based platforms, constraining engagement with newer forms of digital payments (Ali et al 2024; Panda et al 2022).

Network instability is another pervasive challenge. Unreliable or slow connections frequently cause payment failures at the point of sale, which discourages users and weakens confidence in the technology (Suryono et al 2020; Widayani et al 2022). These technical shortfalls mean that even willing users face barriers beyond their control, such as mobile money transfers timing out due to weak signals or online portals becoming unusable in areas without dependable power to charge devices (Agarwal and Assenova 2024; Pal et al 2020).

Physical infrastructure gaps reinforce these constraints. In remote regions, the absence of banking agents, ATMs, or cash-out points makes it difficult to convert digital balances into cash, which remains essential for daily transactions (Priya and Anusha 2019; Rana et al 2019). When users must travel long distances to access such services, the practical value of digital payments diminishes substantially. This creates a cycle in which providers hesitate to invest in infrastructure in sparsely populated areas due to low short-term returns, while users adopt Digital payments slowly because local access points are scarce (Imam et al 2022; Widayani et al 2022). Although some innovations attempt to address these deficits, such as USSD or SMS based payment modes designed for low connectivity environments, the evidence indicates that underlying infrastructure weaknesses remain a significant constraint on the scalability of digital finance. Until issues of connectivity, device availability, and power reliability are addressed, Digital payment services will struggle to achieve widespread and sustained adoption in many developing markets (Suryono et al 2020; Pal et al 2020).

Market Fragmentation and Ecosystem Challenges

The structure and maturity of the wider financial ecosystem play a critical role in determining the success of digital payments adoption. In many developing economies, fragmented payment systems and weak coordination between ecosystem actors present substantial obstacles. Studies highlight that digital providers often operate in isolated networks that do not interoperate, meaning that mobile money services, banks, and FinTech applications frequently function as closed loops that limit seamless fund transfers (Ehret and Olaniyan 2023; Hurani et al 2024). This fragmentation reduces the utility of digital payments, as users are unable to transact across different platforms and may be excluded from key segments of the market. The persistence of non-interoperable systems reflects broader gaps in infrastructure development, with unified payment switches and shared digital rails still in early stages across many regions (Noreen et al 2021; Pareek et al 2025). Merchant acceptance also remains uneven, particularly among small retailers who either lack point of sale technology or prefer cash for convenience and informality (Sugeng and Widya Romasindah Aidy 2025; Widayani et al 2022). This limited acceptance constrains where digital money can be spent and contributes to a cycle in which both merchants and consumers wait for the other side to adopt first. Thin and inconsistent agent networks, a

common feature in rural or low-income communities, further weaken the ecosystem by creating bottlenecks for cash-in and cash-out services, leading to liquidity problems and eroding user confidence in system reliability (Priya and Anusha 2019; Rana et al 2020).

Ecosystem constraints are also shaped by the dynamics between FinTech entrants and incumbent institutions. Research notes that established banks and telecom operators, which control key financial infrastructures, may view FinTech startups as competitive threats and create barriers by limiting integration, restricting access to payment rails, or lobbying for regulations that favour traditional models (Sinha et al 2018; Panda et al 2022). Such resistance hinders collaboration and reduces the overall openness of the ecosystem. Power imbalances also make it difficult for startups to form meaningful partnerships, as incumbents often impose terms that limit innovation or restrict data sharing (Shala and Perri 2022; Pareek et al 2025). At the same time, knowledge sharing mechanisms such as incubators, industry consortia, and collaborative platforms remain underdeveloped, reducing opportunities for coordinated problem solving and slowing ecosystem-level learning (Noreen et al 2021; Widayani et al 2022). Together, these challenges create a fragmented and slow-moving financial environment, indicating that improving interoperability, expanding merchant acceptance, strengthening agent infrastructures, and fostering cooperative industry relationships are essential steps for enabling scalable digital payments adoption across developing economies.

Regulatory and Compliance Barriers

The regulatory environment in many developing economies frequently lags behind FinTech innovation, creating significant friction for digital payments adoption. Studies document persistent ambiguity, inconsistent oversight, and restrictive rules that limit the growth of emerging financial services, particularly where existing legal frameworks were designed for traditional banking rather than digital models (Buckley and Webster 2016; Agarwal and Assenova 2024; Rana et al 2019). In several cases, FinTech firms operate with unclear guidance on permissible activities, slowing product rollout as providers anticipate regulatory shifts or conflicting directives from multiple agencies with overlapping authority (Imam et al 2022; Putrevu and Mertzanis 2023). These regulatory uncertainties increase compliance costs and deter investment, especially in environments where authorisation processes remain complex or fragmented (Agarwal et al 2025; Ehret and Olaniyan 2023). Even when regulations are clearly articulated, they can inadvertently reinforce exclusion; stringent Know Your Customer (KYC) requirements or documentation demands often prevent low-income populations without formal identification from accessing digital payment services (Pareek et al 2025; Hassan 2024).

High licensing fees, capital requirements, and rigid compliance obligations further constrain market entry for smaller domestic firms, consolidating advantage among larger incumbents and slowing innovation (Shala and Perri 2022; Rana et al 2019). The literature also emphasises that policy adaptation frequently trails the rapid pace of technological developments, causing delays in the introduction of beneficial innovations such as peer-to-peer transfers, crypto-enabled services, and open banking interfaces (Hurani et al 2024; Putrevu and Mertzanis 2023). Although some regulators have experimented with sandboxes and pilot schemes to encourage safe experimentation, these initiatives remain limited in scale and do not substitute for comprehensive national strategies that integrate digital finance into broader economic planning (Agarwal and Assenova 2024; Ehret and Olaniyan 2023). Overall, the evidence demonstrates that regulatory frictions rooted in unclear rules, burdensome compliance procedures, and slow policy response continue to hinder the smooth adoption and scaling of digital payments in many developing economies (Hassan 2024; Pareek et al 2025).

Organizational and Capability Gaps in Providers

Finally, the literature indicates that barriers are not only on the user side; many FinTech providers and financial institutions in developing economies face organisational limitations and capability gaps that hamper the rollout and scaling of Digital payment services. One central challenge is the difficulty FinTech startups encounter in securing adequate investment, as emerging market ventures are often

perceived by investors as risky due to uncertain regulatory conditions and small or volatile markets (Hassan 2024; Noreen et al 2021). This scarcity of external financing limits the ability of Digital payments innovators to strengthen their technology, expand their operations, or compete effectively with established incumbents, especially when traditional sources of credit are limited and venture funding ecosystems remain nascent (Habash 2025; Panda et al 2022). This funding gap makes it challenging for local Digital payments innovators to develop robust products, expand their operations, or compete with well-resourced incumbents. Limited resources can also affect product quality and reliability, and the high attrition rate of startups has been linked to insufficient capital and weak support infrastructure across several developing markets (Ali et al 2024; Mahmood et al 2023).

Apart from financial constraints, FinTech providers grapple with persistent human capital limitations. Developing and maintaining digital financial platforms requires specialised expertise in areas such as software engineering, cybersecurity, product design, and compliance, yet many regions face acute shortages of such talent (Cele 2023; Payandeh and Babaei 2025). As a result, companies may operate with small or undertrained teams, leading to issues such as weak user interfaces, limited customer support capacity, and security vulnerabilities. The FinTech industry requires a diverse range of skills; however, there is a shortage of skilled talent in the FinTech workforce, making it difficult for startups to recruit and retain qualified professionals. These shortages are compounded by the outward migration of skilled workers and the rapid evolution of the sector outpacing local training pipelines (Imam et al 2022; Bakhshi et al 2024). Organisational readiness within incumbent institutions adds further constraints. Traditional banks, utilities, and government agencies often lack the agility or modernised systems needed to integrate new Digital payment solutions, and issues such as outdated technology, bureaucratic delay, or internal resistance can hinder effective partnerships with FinTech firms (Ehret and Olaniyan 2023; Hassan 2024). Misalignment in revenue models and an underestimation of challenges related to last-mile delivery, customer education, and compliance further contribute to implementation failures. Strengthening provider-side capabilities, therefore, emerges as a critical need, with the literature emphasising improved industry support structures, talent development initiatives, and expanded funding pathways as essential for building a more resilient and scalable Digital payments ecosystem (Habash 2025; Panda et al 2022).

4 Discussion

4.1 Interpreting barriers through a socio-technical payment stack

RQ2 asked how the barriers identified in the review can be organised within a merged socio-technical and layered payment stack framework to identify where constraints originate and where interventions are required. The classification matrix addresses this question by locating each of the 41 first-order barriers and the 8 themes across three layers of the payment stack and six socio-technical dimensions. The analysis shows that barriers to digital payments in developing economies do not occur in isolation. They form a patterned configuration in which constraints at different layers reinforce one another. Persistent reliance on cash, therefore, emerges not simply as an individual preference but as the outcome of a system that is more internally coherent for cash than for digital alternatives.

The patterns observed in the matrix are consistent with established insights in socio-technical systems research, which emphasises that complex technologies operate as interwoven arrangements rather than discrete components. The interdependencies revealed across layers and domains illustrate a socio-technical configuration in which weaknesses in infrastructure, governance, or organisational capability amplify user-level challenges, while user behaviours and cultural expectations shape how technical and institutional features are experienced. This reflects the socio-technical principle that system-level behaviour cannot be understood by examining individual components in isolation because outcomes arise from interactions within the wider configuration (Ahlborg et al 2019).

Table 9: STS - Payment stack Matrix

STS Dimension	User Layer	Middleware Layer	Infrastructure Layer
People	Low digital and financial literacy; hesitation and fear of errors; mistrust; reliance on others; community influence; cash attachment	Provider talent shortages; weak design and security skills; poor collaboration; resistance inside institutions	Digital divide; low population readiness; gender gaps; limited nationwide human capital; brain drain
Process	Confusing onboarding; difficult KYC steps; unclear support and recourse; transaction failures with no guidance	Slow refunds; weak dispute-handling systems; fragmented workflows; rigid compliance routines	Weak national consumer protection; slow regulatory response; outdated governance practices; no unified recourse architecture
Culture	Preference for cash; social norms around informality; community distrust in new systems; reluctance to break habits	Industry conservatism; turf wars; mistrust between incumbents and FinTech's; resistance to interoperability	Societal preference for informal transactions; religious considerations; suspicion toward digital records and state systems
Goals	Unclear value; cost concerns; weak incentives; fear of fees; economic precarity shaping choice	Short-term strategies; weak incentives to collaborate; lack of shared ecosystem goals	Low national prioritization; limited investment in telecom/power; weak long-term FI strategy
Technology	Complex interfaces; language barriers; device limitations; unreliable app performance; authentication problems	Fragmented APIs; lack of interoperability; unstable backend systems; weak fraud detection	Legacy banking tech; outdated telecom; weak cybersecurity; unreliable ID infrastructure
Infrastructure	Poor connectivity; unstable power; limited agents/merchants; device cost; weak support channels	Fragmented payment rails; concentrated markets; weak enforcement; low merchant acceptance	Power instability; patchy broadband; weak identity systems; high device and data cost

4.1 Answering RQ2: What the classification matrix reveals

Table 9 presents the merged framework as a three-by-six matrix. The columns represent the user layer, the middleware layer and the infrastructure layer of the payment stack. The rows represent six socio-technical dimensions: people, process, culture, goals, technology and infrastructure. Each cell lists representative barriers that were derived from first-order codes and grouped into one of the 8 themes.

Reading the matrix gives three core insights. First, barriers are distributed across all three layers of the stack. Problems are not confined to user attitudes or to basic infrastructure; they appear at every stage from consumer interaction to organisational systems to national foundations. Second, similar patterns recur along the rows. Third, vertical relationships between cells show cascades and feedback loops, where weaknesses in one layer generate or amplify barriers in others. The following subsections elaborate on these points.

4.2 The user layer: visible frictions as system-level symptoms

The user layer is where people interact directly with applications, agents and customer support, and it is here that many of the most visible barriers to Digital payments adoption emerge. The matrix groups together challenges that policymakers and product teams commonly recognise low levels of digital and financial literacy, fear of making mistakes, mistrust of providers, confusion during onboarding, difficulty with know your customer procedures, weak recourse, language mismatches and inconsistent application performance. These barriers are often interpreted in the literature as behavioural deficits or signs that users lack the willingness to embrace new technologies. Yet the matrix points to a more structural interpretation. From a socio-technical viewpoint, user experience is shaped by the alignment

between human capability, interface design and institutional safeguards. When individuals hesitate, abandon transactions or revert to cash, their actions should not be read as simple reluctance to change. Rather, they represent rational judgements in environments where the skills required to use Digital payments are unevenly distributed and where protection in case of error or system failure remains uncertain.

The cultural elements associated with the user layer reinforce this reading. Peer influence, reliance on family members or agents to complete transactions and community-level suspicion of digital records all demonstrate that Digital payments must contend with deeply rooted informal practices based on personal relationships and tangible proof. Cash continues to function within these social infrastructures of trust, offering visibility, immediacy and shared understanding. Digital systems, by contrast, often provide no equivalent mechanisms, particularly for low-income users who lack strong contractual protection or reliable redress when things go wrong. The user layer, therefore, operates as a diagnostic surface. Patterns of mistrust, partial use, abandonment and continued dependence on cash do not simply reflect individual preferences but signal wider misalignments at the infrastructural, institutional and provider layers that sit beneath.

4.3 The middleware layer: organisational bottlenecks and technical fragmentation

The middleware layer encompasses the organisational and technical systems that operate within banks, mobile operators, FinTech firms and payment platforms. The matrix positions this layer as the concentration point for barriers linked to provider capability and ecosystem structure. The people row records shortages of talent, weak design and security expertise and internal resistance to change. The process row captures slow refund cycles, weak dispute handling and fragmented or poorly coordinated workflows. The technology row includes disjointed application interfaces, unstable back-end systems, limited interoperability and insufficient fraud detection. The culture and goals rows highlight industry conservatism, competitive turf battles between incumbents and new entrants and the absence of shared objectives across the wider ecosystem.

These patterns demonstrate that many of the problems visible at the user layer originate upstream within the middleware. Interfaces that appear complex or prone to error frequently reflect constrained design capacity and the pressure to fit new solutions on top of legacy systems, rather than a simple failure to recognise user needs. Slow or inconsistent support and refund processes arise from rigid compliance routines and disconnected internal procedures. Resistance to interoperability is shaped not only by technical difficulty but also by strategic anxieties about cannibalisation, loss of positional advantage and the defence of market share.

This interpretation expands the dominant focus on individual adoption models in the literature. It shows that usability and trust challenges cannot be resolved purely through user education or incremental interface adjustments. They are rooted in deeper organisational capability constraints, governance arrangements and power relations that influence how platforms are built, integrated and managed. The middleware layer, therefore, appears as a central bottleneck. It can either convert infrastructural investments into stable and trustworthy services or dissipate them through fragmentation, limited coordination and internal conflict.

4.4 The infrastructure layer: slow-moving material and institutional constraints

The infrastructure layer brings together the material foundations of Digital payment systems and the high-level institutional arrangements that support them. The technology and infrastructure rows in this column summarise weak or uneven connectivity, unstable electricity supply, patchy broadband, limited identity systems, high cost of devices and data and concentrated telecom and banking markets. The people, process and culture rows add low population readiness, persistent gender gaps, weak national human capital, slow regulatory response, weak consumer protection, limited national prioritisation of inclusive finance and widespread suspicion of digital records and state systems.

These constraints operate largely in the background, yet they shape the environment in which all higher layers of the stack must function. Where identity systems exclude significant parts of the population, providers are compelled to impose burdensome documentation requirements that deter the very users that digital payments are intended to include. Where network coverage is unreliable, even well-executed applications fail repeatedly, creating stories of inconvenience, loss and embarrassment that circulate within communities and undermine trust. Where consumer protection lacks credibility, each unresolved dispute is taken as confirmation that digital money carries unacceptable risk. Where national strategies for digital public goods remain weak or inconsistent, private actors hesitate to make ambitious investments, reinforcing persistent under-provision of infrastructure.

The matrix also shows that these infrastructural constraints have a cultural dimension. In many settings, informal financial practices such as rotating savings groups, cash-based lending and face-to-face settlement are embedded within local norms of reciprocity, privacy and social accountability. Digital payments enter these environments but struggle to replicate the personalised assurances and relational guarantees that accompany long-standing cash-based systems. In this sense, the infrastructure column demonstrates how material and institutional conditions are intertwined with deeper cultural expectations, shaping how Digital payments are perceived and incorporated into everyday financial life.

4.5 Horizontal patterns across the matrix

Horizontal patterns in the matrix show that each socio-technical domain produces a chain of related constraints that stretches consistently across the user, middleware and infrastructure layers. People, processes, culture and goals form a set of interacting horizontal forces that collectively shape payment behaviour and system outcomes. Low digital confidence among users aligns with capability gaps in organisations and wider national skill shortages, forming a coherent line of human capital constraints that limit performance regardless of the layer. Similarly, friction in onboarding or dispute handling reflects procedural weakness inside firms and slow, fragmented regulatory routines at the national level, illustrating how process design issues replicate themselves across the system. Cultural norms favouring cash and informality appear at every layer as user hesitation, industry conservatism and broad societal preference for unrecorded transactions, creating a stable cultural current that reinforces the persistence of cash. Misaligned goals also travel horizontally, with users lacking clear incentives to adopt, firms prioritising short-term strategies and national authorities showing uneven commitment to payment reform, resulting in a system where motivation to change remains weak throughout.

Technology and infrastructure display equally interdependent horizontal behaviour. Interface difficulty and device constraints at the user level mirror fragmented APIs and unstable backend architectures at the middleware level, and extend to legacy systems, uneven telecom quality and weak cybersecurity foundations at the national level. This creates a continuous thread of architectural fragility that restricts performance even when improvements are made in isolated areas. Infrastructure follows the same horizontal logic. Unreliable connectivity or limited acceptance points experienced by users align with liquidity gaps and incomplete agent networks in the middleware layer and originate in wider infrastructural deficits in electricity, broadband and payment rails. These domains, therefore, reinforce each other horizontally, producing systemic constraints that remain present across all layers. Taken together, the horizontal patterns show that digital payment challenges are not layer specific but domain specific, reflecting weaknesses that persist from the point of use to the national foundation. Addressing these domains holistically is therefore essential for enabling meaningful and sustained improvement.

4.6 Vertical patterns

Reading the matrix down the columns brings into view a series of cascades and feedback loops. Failures in the infrastructure column, such as unstable networks or restrictive regulation, appear in the middleware as complex integration workarounds, manual checks and slow or inconsistent processes. These then surface at the user layer as failed transactions, long delays, confusing error messages and

limited avenues for resolution. Over time, such experiences accumulate and feed into wider cultural narratives that frame digital payments as unreliable, risky and inferior to cash.

These cascades help explain why many countries appear locked in what can be described as a low equilibrium configuration. Cash aligns reasonably well with prevailing capabilities, processes, norms and incentives. It remains functional even when networks are unstable, regulatory environments are fragmented and formal identity systems exclude large segments of the population. Digital payments, by contrast, depend on the coordinated operation of multiple layers. If any component of that chain is weak, the reliability of the entire system is compromised, and users have sound reasons to revert to cash. The matrix, therefore, adds precision to ongoing debates about institutional stickiness and infrastructural lag by illustrating where misalignment occurs and how it generates system-level outcomes.

4.7 Implications for policy and practice

The classification matrix carries several implications for policymakers, regulators and industry actors. Interventions that focus solely on the user interface are unlikely to produce sustained change. Education campaigns, interface simplification and promotional incentives may ease short-term friction, but they cannot counter persistent mistrust if transactions continue to fail or if recourse mechanisms remain weak. Improvements at the user layer must be matched by policies that strengthen infrastructure reliability, enhance consumer protection and build organisational capability within providers. Equally important is the role of interoperability and coordination at the middleware layer. When banks, telecom firms and FinTech providers collaborate on shared rails, identity systems and dispute handling mechanisms, many barriers in the process and technology rows diminish. Regulators can support this by establishing clear rules, promoting open standards and aligning incentives through coherent licensing and oversight structures.

National strategies for digital public infrastructure emerge as critical enablers. Investments in stable connectivity, digital identity, shared payment rails, and credible consumer protection systems address multiple constraints in the infrastructure column simultaneously. These investments require time and resources, yet they provide the foundations for an inclusive digital payment ecosystem. Interventions must also be crafted with cultural dynamics in mind. Efforts to formalise transactions through digital channels should acknowledge the legitimacy of informal practices and retain valued features such as flexibility and relational trust. Partnerships with community-based organisations, religious leaders and informal financial groups can help translate digital tools into forms that resonate locally rather than framing them as purely technical substitutes for cash.

4.8 Implications for theory and future research

The findings also extend ongoing theoretical debates. In technology adoption research, the matrix shows that models centred on perceptions of usefulness, ease of use, trust and risk capture only a narrow slice of the forces shaping behaviour. These perceptions arise not only from individual cognition but from lived experience shaped by infrastructural reliability, organisational capability and regulatory protection. Adoption theory can therefore benefit from integrating stack-based and socio-technical perspectives, treating constructs such as perceived risk as emergent outcomes of misalignment across multiple layers rather than strictly psychological variables. Future work can also draw on Interpretive Structural Modelling to analyse layered challenges more systematically. This method structures expert insight to reveal how system elements influence each other, producing clear hierarchies that expose root drivers, dependent conditions and points for targeted intervention, which is valuable for clarifying complexity in constrained settings (Warfield 1974).

For research on financial inclusion and digital infrastructure, the review underscores the value of viewing payment systems as layered socio-technical arrangements rather than isolated products or provider initiatives. Comparative work can use the matrix as a framing device to examine how different mixes of infrastructural investment, regulatory design and provider collaboration shape adoption

trajectories. Longitudinal studies can trace how interventions introduced at one layer propagate through the system and reshape user experience over time. More broadly, the matrix creates a transparent link between granular evidence and system-level interpretation. Future reviews or case studies can adapt this structure to other technologies and regions, enabling cumulative comparison while remaining sensitive to contextual variation.

4.9 Limitations

The discussion should be interpreted considering several limitations. The matrix is derived from forty published studies that are unevenly distributed across countries and concentrated largely on mobile payments in a small number of major emerging economies. Grey literature, internal industry reports and research published in languages other than English were not systematically incorporated and could reveal additional categories of barriers. In addition, the placement of barriers within specific cells of the matrix involves interpretive judgement, even though this process was anchored in a rigorous coding procedure that drew on NVivo memos and repeated engagement with the original texts. The matrix should therefore be understood as an empirically grounded interpretation rather than a definitive taxonomy. Within these boundaries, however, it offers a structured and evidence-based way of conceptualising Digital payment barriers that can be refined, extended and empirically tested in future research.

5. Conclusion

This systematic review has brought together a dispersed body of scholarship on digital payment and wider FinTech adoption in developing and emerging economies and reinterpreted it through a socio-technical lens. Drawing on 40 empirical and conceptual studies, the review identified 41 distinct barriers that were synthesised into 8 higher-order themes spanning user capability and trust, social and cultural influences, infrastructure and connectivity, market and ecosystem coordination, regulation and compliance, organisational capability and economic and service design constraints. This thematic structure answers RQ1 by providing a comprehensive catalogue of the forces that inhibit digital payment uptake across contexts.

To address RQ2, the review organised these themes within an integrated socio-technical and payment stack framework. The resulting three-by-six classification matrix locates each barrier in relation to both its dominant socio-technical dimension and the layer of the payment system where it primarily manifests: user, middleware or infrastructure. This framework shows that barriers are not isolated problems but elements of a patterned configuration in which capability gaps, process fragmentation, cash-centred norms and misaligned incentives recur across layers and reinforce one another. It helps explain why cash remains a coherent default in many settings, while digital payments depend on a chain of technical and institutional conditions that is often fragile. The matrix therefore offers both a typology and a system-level explanation of digital payment failures, demonstrating that adoption outcomes emerge from the alignment of technology, institutions and everyday practice rather than from any single factor.

Theoretically, the review advances the use of socio-technical systems thinking in FinTech research. Existing work tends to treat barriers either as individual attitudes or as standalone infrastructural or regulatory constraints. By explicitly combining a layered payment stack with socio-technical dimensions, this study shows how barriers cut across micro, meso and macro levels, and how symptoms observed at the user interface often reflect deeper organisational and infrastructural conditions. The framework gives concrete form to the principle of joint optimisation: inclusive digital payment systems require simultaneous alignment of human capability, cultural expectations, organisational processes,

technological design and institutional rules. It therefore enriches both the FinTech and socio-technical literatures with a model that connects interface-level experience to the underlying architecture of payment ecosystems.

The findings also carry clear implications for policy and practice. The matrix highlights that interventions concentrated at a single point in the system are unlikely to shift behaviour durably. Upgrading connectivity or expanding smartphone access will not achieve sustained adoption if consumer protection remains weak and providers lack the organisational capacity to deliver reliable services; likewise, literacy campaigns will struggle if applications remain complex, networks are unstable, and agents are scarce. More promising are strategies that act on several cells of the matrix at once: coordinated investment in digital public infrastructure, regulatory reform that lowers entry and compliance barriers while strengthening recourse, ecosystem-level efforts to build interoperability and shared rails and long-term programmes that enhance digital and financial capability for both users and providers. For practitioners, the classification matrix can function as a diagnostic checklist that helps governments, regulators and firms identify which combinations of technical, organisational and institutional changes are required to move a specific payment system away from a low equilibrium configuration anchored in cash.

Methodologically, the review contributes a combined human and AI-assisted approach to qualitative synthesis. Manual coding in NVivo was complemented by using ChatGPT as a secondary coder that generated independent lists and groupings of barrier concepts. These AI outputs were always checked against the primary texts, yet they provided a useful form of triangulation, drawing attention to potential omissions and encouraging revisiting of borderline cases. Organising the consolidated coding structure within the socio-technical stack framework further strengthened analytic transparency by allowing readers to trace the route from first-order statements in the literature to the abstract structure of the matrix. This combination of systematic review protocol, qualitative analysis software, AI support and framework-based synthesis offers a transferable template for future reviews of complex digital innovation fields.

The review also points to important directions for further research. The evidence base remains dominated by cross-sectional studies of mobile payments in a limited set of large emerging economies. Longitudinal and comparative research is needed to examine how barrier configurations evolve, how interventions at one layer propagate through the system and how regional differences in culture, regulation and infrastructure shape the effectiveness of policy mixes. Future studies could deepen socio-technical analysis by exploring how digital payment practices are negotiated within households, firms and communities, and how power relations between incumbents, new entrants and regulators shape which configurations of the ecosystem become stabilised.

Taken together, the findings suggest that achieving inclusive digital payment systems in developing economies requires more than incremental technical upgrades or narrow demand-side campaigns. It calls for a deliberate rebalancing of the socio-technical system so that digital payments become as coherent and trusted as cash across layers of everyday life, organisational routines and national infrastructure. The classification matrix developed here provides one step toward that goal: a structured way to see where the system currently fails and a guide for designing interventions that act across technology and society in concert. By adopting such integrated perspectives, researchers and practitioners can work toward digital financial ecosystems that are not only innovative but also resilient, inclusive and attuned to the lived realities of the communities they are intended to serve.

Appendix

Authors	Context	Methodology	Key Barriers Identified
(Agarwal and Assenova 2023)	78 (Emerging Economies)	Difference-in-Differences (DID) Design, Institutional Change Literature	Institutional Voids in Credit Markets: Lack of credibility enhancers (credit history), lack of credit information analyzers (credit bureaus), underdeveloped aggregators & distributors (physical/digital banking infrastructure), low digital literacy, poor connectivity.
(Agrawal et al. 2025)	India	Interpretive Structural Modeling (ISM), Technology Adoption Models	Driving Barriers: Lack of Knowledge (C9), Lack of Literacy (C4), Network Issues (C8). Dependent Barriers: Perceived Usefulness (C2), Perceived Risk (C3). Intermediary Barriers: Mindset (C5), Lack of Information (C1), Complexity (C7), Lack of Trust (C6).
(Aidonojie et al. 2023)	Nigeria	Doctrinal Legal Research + Descriptive/Analytical Statistics	Legal/Regulatory: No current primary legal framework (86.2%), No formal legal debt recovery (94.1%), Breach of data privacy by Fin-Techs for debt recovery (74.7%). Socio-Economic/Infrastructure: High rate of technological illiteracy (69.1%), High interest rates, poor power/internet supply, incidence of fraud.
(Ajouz et al. 2023)	Emerging Markets (Expertise focus: MENA, Southeast Asia)	Conceptual Framework based on FinTech Ecosystem dimensions (Talents, Demand, Policy, Capital)	Policy/Regulation: Uncertain/strict regulations, difficulty in registering/licensing. Capital/Investment: Political and economic instability/volatility, difficulty obtaining funding (perceived risk). Demand/User: Lack of trust, low financial literacy (results in scams/fraud/over-borrowing). Infrastructure: Inadequate financial infrastructure, need for digital and communication infrastructure.
(Ali et al. 2019)	Pakistan	Integrated Framework (TAM, DOI, UTAUT)	Significant Negative Barriers: Stress, Unavailability of facilitating condition (infrastructure/literacy). General Hindrances: Low awareness, complexity of app interfaces, limited security/privacy, low digital literacy.
(Bakhshi et al. 2024)	India	Interpretive Structural Modeling (ISM)	Driving Barriers (Level 4): Lack of Literacy (B7), Lack of Financial Literacy (B9), Lack of Awareness (B5). Dependent Barrier (Level 1): Cash Culture (B6). Intermediary Barriers: Perceived Ease of Use (B8), Social Influence (B4), Perceived Risk (B1), Lack of Trust (B2), Lack of Perceived Benefit (B3).
(Braido et al. 2021)	Brazil	Case Study Method, Entrepreneurship Literature	Regulatory: Difficult/unclear legislation, lack of specific regulation. Ecosystem: Conflict/boycotts by major players (banks), difficulty finding aligned partners. Capital: Investment needs, difficulties fundraising (investor culture), low scale-up capacity. Human Resources: Scarcity of qualified HR (IT/financial market knowledge). User/Culture: Mistrust in new payments (cultural issue), poor internet connection (rural areas).
(Buckley and Webster 2016)	Developing Countries	Customer Journey (Contrast with Process Mindset), Institutional Quality Theory	Institutional Quality: Weak rule of law, poor contract enforcement, large informal economy. Access/Cost: Physical distance to banks (high monitoring/transaction costs), high costs due to low competition. Human/Design: Low financial literacy, need for formal documentation (excludes informal workers). FinTech Design Flaw: Developers/customers have no personal similarities (failure to appreciate local customer journey).
(Butt and Khan 2019)	Pakistan	Case Study Methodology, Exploratory Study	Customer Acceptance: Reluctance to adopt financial innovations. Human/Literacy: Low literacy rate (major barrier), technological literacy is low. Economic/Cost: High poverty rate, people are cost conscious. Trust/Security: Less trust on online services, security issues/hackers. Infrastructure: Needs Fin-Tech infrastructure upgrade, many people live in rural areas where no banks/facilities.
(Cele 2023)	South Africa	UTAUT Extension (Combined with TAM Constructs)	Negative Determinants: Perceived Cost (negative effect, $\beta=-1.000$), Perceived Risk (negative effect, $\beta=-0.150$). General Hindrances: Lack of facilitating conditions (infrastructure/support) is a key impediment, cybercrime fears, lack of trust (scepticism towards new entrants).
(Ehret and Olaniyan 2023)	Nigeria	Institutional Theory (Constitutive Rules), Social Action Theory	Institutional Voids: Underdeveloped financial institutions/payment infrastructure. Supply-Side Challenges: Telcos suspicious of mobile money operators (MMOs), regulatory uncertainty (at the start). Adoption Challenges: Use of cash problem (inertia), digital transaction phobias and mistrust among the unbanked. Agent Network Challenges: Competition for best agents, financing agent network buildout (resource intensive).
(Habash 2024)	Palestine	Generalized Linear Model (GLM) Regression, Theory of Planned Behavior (TPB)	Economic/Income: Economic conditions and low individual income (major formidable obstacles). Cost: Cost of FinTech services discourages use (negative coefficient). Trust/Attitude: Distrust in providers hinders access/usage for middle/high-income users. Education/Gender: Negative impact on access/usage. General Exclusion: Low income leads to Voluntary Financial Exclusion (VFE), perceived financial services as luxuries, poverty.
(Hassan 2025)	Egypt	Interpretive Structural Modeling (ISM), Delphi Method	Independent Set (Driving): Lack of Knowledge/Awareness, Social Culture, Digital Illiteracy, Lack of Innovativeness, Demographic Factors. Linkage Set: Security, Privacy. Dependent Set (Outcome): Lack of Trust, Complexity, Compatibility/Usage, Inaccessibility. General Preference: Preference for face-to-face interaction and traditional paper procedures.

(Higgo and Botha 2025)	Pakistan	Structural Equation Modeling (SEM) - Extended UTAUT	Core Barriers: Perceived Risk (financial, security, performance) strongly affects adoption intention. Anxiety/Stress (negative predictor). Digital Divide (low awareness/literacy, poor internet access). Trust is key mediator.
(Hurani et al. 2024)	South Africa	Thematic Analysis, Dynamic Capabilities, Open Innovation, Stage-Gate	Talent/HR: Scarcity of skilled workers, talent emigration (brain drain), skill gap. Infrastructure: Unreliable/inadequate infrastructure, limited high-speed internet, technical complexities of legacy systems. Adoption/Market: Slower client adoption, bias for cash transactions, cultural resistance to change. Regulatory: Slow policy adaptation, data localisation requirements (barriers). Finance: Funding/resource constraints.
(Imam et al. 2022)	Jordan	Extended Technology Adoption Model (TAM)	Core Barriers: Perceived Risk (financial, privacy, security) strongly reduces adoption intentions. Lack of Trust in the technology/platform. Complexity and low perceived ease of use.
(Irianto and Chanvarasuth 2025)	SAARC & ASEAN	FinTech Opportunity Index (FOI), Global Findex Database (GFD)	Primary Barrier: Insufficient funds (top barrier in both regions, especially SAARC). Other Barriers: Financial services expensive, mistrust, missing documentation (ASEAN), services unneeded (subjective barrier). Cultural Barriers: Tendency to borrow/save from friends/family (challenge to formal finance), cash preference. Demographic Barriers: Females and elderly (65+) are less likely adopters.
(K and Kanniammal 2025)	Indonesia	Structural Equation Modeling (SEM) (Extended TAM, UTAUT, TPB)	Insignificant Barriers: Perceived Cost, Trust, Customer Engagement, and Complexity (likely due to MSME focus/context). General Challenges: Low level of digitization among MSMEs, low education level of MSME managers, low security standards (risk factor).
(Kabengele and Hahn 2021)	46 Emerging Countries	Fuzzy-Set Qualitative Comparative Analysis (fsQCA), Institutional Theory	Institutional: Underdeveloped financial markets (can be opportunity OR barrier), unreliable regulation (can be impediment), underdeveloped mobile network infrastructure, weak educational institutions/low consumer readiness/illiteracy. Firm: Lack of large agent network, insufficient financial resources/capital for scale-up.
(Kuriakose and Sajoy 2023)	India	Polynomial Trendline Projection (Time-series data)	Infrastructural Challenges: Increased failure rate on transactions (technical glitches), complexity of UPI payment architecture, lack of timely implementation of UDIR. Accessibility Challenges: Challenges in rural areas, limited Internet connectivity, lack of digital literacy (rural areas), P2M reluctance (users reluctant to make high-value payments to merchants).
(Loke et al. 2025)	India	Regression Analysis, Innovation Resistance Theory (IRT)	Barriers (Negative Impact): Usage Barrier ($\beta=-0.459$), Value Barrier, Traditional Barrier, Risk Barrier, and Image Barrier (all significantly negative). General Concerns: Security-related issue (recalling more than one ID/password), network problems, unsuccessful transactions, merchant rejection. Socio-Economic: Low-income level, unawareness, lack of interest.
(Mohd and Razali 2024)	Malaysia	UTAUT Extension (Trust & Government Intervention as Mediators)	Trust Issues (Mediating): Heightened financial fraud risks, data breaches, and scams negatively impact consumer trust. Facilitating Conditions (FC): FC does not directly influence adoption (insignificant finding). Policy Gaps: Consumers still expect more government intervention (to enforce consumer protection, improve awareness).
(Mukhopadhyay and Upadhyay 2022)	Malaysia	PLS-SEM (Extended UTAUT)	Core Barriers: Perceived Risk (financial, security) strongly hinders adoption. Resistance to Change (negative predictor). Lack of Knowledge and Literacy remain major constraints. Infrastructure issues.
(Nalluri and Chen 2024b)	India	Institutional Theory (Intervention/Inertia), Digital Platform Theory	Pre-Intervention Barriers (Inertia): Universal acceptability of cash, cultural preference for cash, reluctance/inability to use technical solutions, intention to evade taxation. General Barriers: Lack of continuance intention once constraints are withdrawn, unwillingness of consumers/retailers, technology limitations.
(Noreen et al. 2021)	India	UTAUT2 Extension (Structural Equation Modeling)	Core Barriers: Trust and Perceived Risk (significant negative predictors). Perceived Cost (significant negative predictor). Habit (Inertia against switching from cash/old methods).
(P and C 2019)	Pakistan	PLS-SEM (Extended TAM)	Core Barriers: Perceived Risk (security/privacy concerns), Lack of Trust. Other Negative Factors: Cost and Complexity.
(Pal et al. 2020)	India	Thematic Analysis, Contextual Factors of Mobile Payment	Digital Divide: Lack of Digital Literacy and Illiteracy (functional literacy). Infrastructure/Cost: Unreliable mobile network connectivity, high cost of data. Risk/Trust: Trust and perceived security risk.
(Panda et al. 2022)	India	Structural Equation Modeling (SEM) (Extended TAM, UTAUT)	Core Barriers: Perceived Risk (security/privacy) significantly reduces adoption intent. Lack of Digital Literacy/Knowledge (strongest predictor). Infrastructure/Internet Connectivity (negative predictor). Socio-Economic Factors: Income, age, education influence adoption.
(Pareek and Maidullah 2025)	Iran	Structural Equation Modeling (SEM) (Extended UTAUT)	Core Barriers: Perceived Risk (privacy/security/financial) strongly deters adoption. Lack of Awareness/Knowledge (negative predictor). High Cost of using the technology. Complexity and perceived difficulty.
(Payandeh and Babaei 2025)	India	Survey, Regression Analysis	Core Barriers: Lack of Digital Literacy, Lack of Internet Access/Connectivity. Risk/Trust: Security and Privacy concerns.
(Priya and Anusha 2019)	India	Review of Literature/Conceptual Framework	Regulatory: Lack of regulatory clarity. Risk/Infrastructure: Security issues, Low internet access, digital illiteracy. Social/Cultural: Resistance to change, preference for cash culture.
(Putrevu and Mertzanis 2023)	India	Structural Equation Modeling (SEM) (Innovation Resistance Theory)	Barriers (Negative Impact): Usage Barrier (difficulty of use), Risk Barrier (financial/security risk), and Image Barrier (negative public perception) significantly impede adoption. Traditional Barrier (cash culture) is a key negative factor.

(Rana et al. 2019)	India	Interpretive Structural Modeling (ISM), Thematic Analysis	Driving Barriers: Lack of Robust Digital Infrastructure, Low Digital Literacy and Awareness. Linkage Barrier: Trust and Security Concerns, Lack of Regulatory Clarity/Support. Dominant Barrier: Cash-based economy and lack of customer awareness.
(Rana et al. 2020)	India	Structural Equation Modeling (SEM) - Extended UTAUT	Core Barriers: Perceived Risk (financial, performance, privacy) significantly deters adoption. Anxiety about using new technology is a strong negative factor. Trust is a key predictor mediating other factors.
(Shala and Perri 2022)	Kosovo	Structural Equation Modeling (SEM) - Extended TAM	Core Barriers: Perceived Risk (security/privacy issues) significantly reduces intention to adopt. Lack of Trust in the technology and system is a barrier. Complexity and low perceived Ease of Use discourage adoption.
(Singh et al. 2025)	India	Structured Equation Modeling (SEM) - Extended UTAUT	Core Barriers: Perceived Risk is a significant negative determinant. Digital Divide factors (age, income, education) influence adoption. Trust and perceived value are key positive factors.
(Sanjay Sinha et al. 2018)	India	Structural Equation Modeling (SEM) - Extended UTAUT	Core Barriers: Perceived Risk (security, privacy, operational risk) significantly deters adoption. Lack of Trust is a critical issue for mobile wallets. Lack of Digital Literacy is a major constraint.
(Sugeng and Aidy 2025)	Indonesia	PLS-SEM (Extended TAM)	Core Barriers: Perceived Risk (financial/security) strongly deters adoption. Lack of Trust in service providers. Lack of Digital Literacy/Knowledge (negative predictor). Social Influence (negative impact).
(Suryono et al. 2020)	Indonesia	Structural Equation Modeling (SEM) - UTAUT2	Core Barriers: Perceived Risk (privacy/security/financial) strongly deters adoption. Price Value (negative predictor). Habit is a strong positive predictor (inertia to change once adopted).
(Widayani et al. 2022)	Indonesia	Structural Equation Modeling (SEM) (Extended TAM, TOE)	Organizational Barriers: Lack of Knowledge/Training, Lack of Resources (financial, human). Environmental Barriers: Lack of Government Support (regulatory/incentives), Complexity of regulations, Lack of IT Infrastructure.

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Exploring the Value of Strategic Foresight in Enhancing the Adaptiveness of National Innovation Policy
Yenpat Khamdaengyodtai

The Nature of the Research
This research investigates the governance of 'wicked problems' within the National Innovation Policy (NIP) domain, characterized by volatility, uncertainty, complexity, and ambiguity (VUCA). NIP is uniquely challenged by deep uncertainty and long time horizons, often leading to path dependency where states remain locked into declining technological trajectories. While scholarly consensus identifies 'adaptive capacity' as a critical institutional quality, a significant gap remains in understanding the specific mechanisms that embed this capacity within the machinery of government. This study explores strategic foresight as a key instrument of anticipatory governance to bridge this gap.
Why it is Worth Studying
Understanding how to systematically design and cultivate adaptive implementation is vital for the survival of national innovation systems. This research moves beyond the rhetoric of "adaptiveness" by empirically investigating the causal pathways through which foresight influence manifests. It addresses the practical need for states to move from reactive problem-solving to proactive, experiment-oriented policy cycles.
Key Literature Pointers
The research is grounded in the National Innovation Systems (NIS) framework and the typology of policy adaptiveness—categorized as robustness, resilience, and transformative capacity. It builds on the theory of anticipatory governance and the functional roles of foresight in innovation policy.
Methodology
A qualitative, multiple-case study design is employed, focusing on national innovation systems with varying levels of maturity and different institutional models of foresight integration. The core analytical method is Process Tracing, chosen for its ability to "open the black box" of causality and test hypothesized mechanisms within complex policy cycles. Evidence is triangulated through semi-structured interviews and analysis of primary policy documents.
Expected Challenges
A primary challenge involves addressing 'equifinality', where observed policy adaptation may result from alternative factors such as crisis-driven learning or external political pressure. Furthermore, capturing diagnostic evidence for cognitive and institutional shifts requires deep analysis to distinguish genuine foresight influence from retrospective rationalization by policy actors.
Anticipated Impact
The research aims to provide an empirically grounded model of how states build 'dynamic capabilities' through foresight. Practically, it will offer actionable recommendations for designing governance interventions that lead to more resilient and adaptive innovation policies.

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Title:

Environmental Institutional Diversity and MNE's Corporate Environmental Performance: The Moderating Role of Supranational Institutional Anchoring

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ABSTRACT

Does exposure to diverse institutional environments enhance or hinder multinational enterprises' (MNEs') environmental performance? Prior research often emphasises the coordination costs associated with institutional heterogeneity. We argue instead that domain-specific institutional diversity can generate governance benefits. Focusing on environmental regulatory stringency, we conceptualise environmental institutional diversity (EID) as variation in host-country environmental governance across a firm's international footprint rather than generic institutional distance. Exposure to heterogeneous environmental regimes increases disparities in environmental performance across subsidiaries and heightens regulatory and reputational risks because stakeholders evaluate MNEs holistically. To mitigate these risks, firms are incentivised to reduce internal environmental performance variance by standardising environmental practices and upgrading underperforming subsidiaries, thereby improving corporate environmental performance (CEP). We further argue that the effectiveness of this mechanism depends on supranational institutional anchoring, which provides shared regulatory benchmarks and harmonised monitoring systems that increase both the incentives and organisational capacity for firms to implement firm-wide environmental standardisation. However, this amplifying effect weakens as firms expand across multiple markets within the same supranational regime, where environmental governance becomes routinised within established compliance systems. Using panel data on U.S.-headquartered MNEs and their global subsidiaries from 2010-2023, we find evidence consistent with these arguments.

Keywords: Institutions, Climate Change, Corporate Environmental Performance

1. INTRODUCTION

Imagine a multinational enterprise (MNE) operating across a global landscape. Its subsidiaries are spread across North America, Europe, Asia, and Africa, each governed by distinct environmental regulations. In some regions, the company navigates highly stringent regulations, while in others, environmental laws are more relaxed or even loosely enforced. This global tapestry of diverse regulations, standards, and enforcement creates a dynamic challenge for the MNE. How does it manage this institutional diversity, that is, the variation in regulatory frameworks across countries where its subsidiaries operate, and more importantly, how does it impact their environmental performance (CEP)? Further, for an MNE operating across multiple countries, it needs to navigate cross-border institutional complexity, home-based, host-based, and supranational, and the interaction between these (S. Hartmann et al., 2022a; Sun et al., 2021). MNEs face a multilevel governance system in which supranational rules clash or combine with national interpretations, creating a web of compliance obligations. In this situation, how does a firm's supranational institutional anchoring affect its incentives and ability to thrive in such a complex institutional environment? These are the puzzles this study aims to unravel.

Although multinational enterprises (MNEs) inherently operate across multiple countries, they differ substantially in the degree of environmental institutional diversity (EID) they face. Even when firms operate in the same number of host countries, the institutional conditions they encounter may vary markedly, as some expand into relatively similar environments while others span highly heterogeneous regulatory regimes (Lundan & Li, 2019). MNEs also differ in their economic dependence on particular host countries, meaning that institutional contexts vary in strategic importance depending on the scale and significance of local operations (Wu & Park, 2019). As firms expand across countries with heterogeneous environmental regulations, they confront not only divergent compliance requirements but also greater managerial complexity, visibility, and accountability exposure. A central issue is that environmental performance is increasingly evaluated at the level of the corporation rather than the individual subsidiary. Because multinationality makes firms more visible to globally dispersed stakeholders, misconduct in any part of the MNE's international footprint can become salient to transnational audiences and trigger legitimacy challenges that extend beyond the focal location (Cuervo-Cazurra et al., 2021). This risk is amplified because MNE reputation is largely "non-location-bound," allowing negative information about localised

corporate social irresponsibility to diffuse rapidly across stakeholder and media networks and prompt headquarters-level responses aimed at restoring control and credibility (Wang & Li, 2019). More broadly, legitimacy spillover theory suggests that stakeholders often infer the character of the whole organisation from the actions of a single affiliate, so environmental failures in one subsidiary can generate reputational spillovers to the entire MNE (Haack et al., 2014). Recent evidence further shows that irresponsible behaviour in one market can damage overall corporate reputation and even harm the performance of foreign subsidiaries elsewhere in the MNE network (Nardella et al., 2023; Nuruzzaman et al., 2024). Taken together, this literature suggests that MNEs care about EID and CEP because greater environmental institutional diversity increases the likelihood of uneven subsidiary performance, while environmental failures in any one location can produce firm-wide reputational, legitimacy, and regulatory consequences.

International business research highlights that MNEs possess distinctive organisational capabilities, including internal governance systems, capital allocation mechanisms, and knowledge transfer processes that allow them to mitigate cross-country institutional frictions (Allen et al., 2025; Pinkse & Kolk, 2012b). These capabilities enable firms to develop firm-wide environmental strategies, diffuse best practices across subsidiaries, and respond proactively to environmental pressures even in the absence of harmonised global regulation. Consequently, MNEs play a central role in addressing climate change by operating at the intersection of fragmented institutional environments and transnational organisational capabilities.

Corporate environmental performance refers to the extent to which a firm reduces the environmental impacts of its activities, often reflected in outcomes such as emissions, waste, and resource use, relative to an appropriate benchmark (e.g., firm size/production context) and is commonly operationalised using emissions-based indicators, environmental ratings, or other outcome- and process-based metrics (Claver et al., 2007; Ilinitch et al., 1998; King & Lenox, 2001a). Existing research identifies a range of interrelated determinants of CEP, encompassing internal organisational, governance, and strategic factors, as well as external influences including national institutional conditions (regulatory, cultural, and social norms) and market- and stakeholder-based pressures. A substantial body of cross-national research has convincingly demonstrated that formal institutions shape CEP by structuring firms' incentives, constraints, and legitimacy expectations. In particular, economic institutions (e.g.,

market freedom and economic development), legal institutions (e.g., rule of law, regulatory quality, and environmental regulation stringency), and political institutions (e.g., press freedom, ideology, and geopolitical conditions) have been shown to systematically influence firms' environmental and ESG outcomes through coercive pressures, enforcement credibility, and heightened stakeholder visibility (Aguilera-Caracuel et al., 2013; Amer, 2023; Ellimäki et al., 2023; J. Hartmann & Uhlenbruck, 2015; Ioannou & Serafeim, 2012; Kim et al., 2025). Collectively, this literature has advanced understanding by establishing that CEP is not solely a function of firm-level resources or strategies but is deeply embedded in national institutional contexts.

However, despite these advances, prior research overwhelmingly conceptualises institutions as country-level attributes and examines their effects either in isolation or through dyadic home-host comparisons, implicitly assuming that firms respond to one institutional environment at a time. This approach under-theorises the reality that multinational enterprises (MNEs) operate simultaneously across multiple countries characterised by distinct regulatory regimes, enforcement practices, and policy orientations. Such simultaneous exposure gives rise to institutional diversity, defined as the heterogeneity of institutional environments across an MNE's international portfolio (Banalieva & Dhanaraj, 2013; Jackson & Deeg, 2008a; Morgan, 2009; Pisani et al., 2018; Verbeke et al., 2014; Zhao et al., 2020a). While related work on institutional distance and environmental standardisation demonstrates how differences between home and host countries shape firms' adaptation and standardisation choices (Aguilera-Caracuel et al., 2014), this literature remains largely dyadic in nature and risks conflating institutional distance with host-country institutional profiles (van Hoorn & Maseland, 2016). Moreover, the concept of distance assumes symmetry in cross-national differences (Shenkar, 2001a), despite the fact that the costs of operating effectively in unfamiliar institutional environments are often asymmetric (Lundan & Li, 2019).

Building on the concept of institutional diversity, our study introduces environmental institutional diversity, which refers to the variation in institutions governing environmental protection and sustainability across the countries in which an MNE operates. We argue that institutional diversity is inherently domain-specific: the institutional dimensions that matter depend on the focal outcome and the mechanisms being theorised. Prior IB scholarship cautions that treating institutions "thinly" through generic, highly aggregated indicators can mask the causal pathways through which particular institutional domains shape firm

behaviour, because institutional effects are often rooted in domain-specific arrangements and their interactions rather than in an undifferentiated level of "institutional quality" (Jackson & Deeg, 2008). Building on this critique, Lundan and Li (2019) emphasise that institutional diversity is multidimensional and that meaningful theorising requires attention to which institutional features vary across countries and are most relevant for the strategic task at hand. Understanding EID is therefore essential for advancing theory beyond level-based, country-centric explanations toward a more realistic account of how MNEs experience and respond to heterogeneous institutional environments in pursuing environmental performance.

Although institutional diversity has traditionally been framed as a source of barriers, uncertainty, and liability, its potential advantages have received comparatively limited scholarly attention (Stahl et al., 2016). Rather than focusing exclusively on minimising institutional distance, MNEs may derive strategic benefits by engaging with and leveraging diverse institutional arrangements as sources of learning and advantage. An excessive emphasis on the risks associated with heterogeneity may therefore prevent firms from recognising and exploiting the resources and opportunities that institutional diversity can generate (Lundan & Li, 2019). Consistent with a portfolio view of multinationality, emerging research suggests that the configuration of an MNE's host-country institutional environments, rather than only the average level of institutional quality, shapes important strategic and performance consequences. For example, Arregle et al. (2016) show that regional institutional diversity in an MNE's existing foreign footprint influences how it structures subsequent FDI location choices, strengthening the degree to which expansion is organised regionally. Complementing this, Wu and Park (2019) demonstrate that international institutional complexity affects MNEs' innovation performance, implying that exposure to diverse institutional logics can generate learning benefits up to a point before coordination burdens dominate. Finally, Zhao et al. (2020) show that host-country institutional diversity conditions the multinationality-performance persistence relationship, highlighting that institutional variety can enhance flexibility and risk-hedging benefits, but excessive diversity can undermine them due to rising managerial complexity.

International business scholarship increasingly calls for multilevel institutional approaches that move beyond an exclusive focus on national institutions, recognising that supranational governance arrangements coexist with and moderate national institutional contexts, thereby blurring national boundary conditions and shaping firm behaviour, particularly in

sustainability-related domains (S. Hartmann et al., 2022b; Kano et al., 2025). Supranational institutions are governance arrangements located above the nation-state, created through the delegation or pooling of authority by states and other actors, and endowed with the capacity to formulate, coordinate, and enforce rules, norms, or standards that shape behaviour across national boundaries (Abbott & Snidal, 2021; Hartmann et al., 2022). Institutional anchoring refers to the process through which an organisational practice or arrangement becomes stabilised and legitimised by being linked to credible institutional reference points (e.g., elements of prevailing logics), thereby reducing contestation and enabling persistence over time (Malhotra et al., 2021). Prior research suggests institutional anchoring can condition the effects of cross-national institutional heterogeneity by supplying shared rules, norms, and regulatory standards that sometimes bridge institutional differences or supplement national regulatory gaps, thereby helping firms operate across inconsistent national regimes (Abbott & Snidal, 2000; Djelic & Sahlin, 2006; S. Hartmann et al., 2022a; Mattli & Woods, 2009).

However, despite growing recognition of supranational institutions and explicit calls to examine cross-border institutional complexity (S. Hartmann et al., 2022a; Sun et al., 2021), existing research has largely treated supranational institutions as direct contextual forces or background conditions, rather than theorising how firms' anchoring in supranational frameworks conditions the performance implications of cross-national institutional diversity. This gap is particularly salient in the climate domain, where governance remains fragmented and institutional failures persist (Kano et al., 2025; Pinkse & Kolk, 2012b). Consequently, we lack a systematic understanding of whether, and how, supranational institutional anchoring reshapes the relationship between EID and CEP, an omission that limits theory development at the intersection of institutional diversity, multilevel governance, and sustainability.

Against this backdrop, we aim to examine two main research questions: (1) How does environmental institutional diversity affect MNEs' CEP? (2) Does supranational institutional anchoring moderate the relationship between EID and CEP? To address these research questions, we construct a panel dataset of U.S.-headquartered MNEs covering the period 2010 to 2023. The final analytical sample comprises 344 firms with international subsidiaries and complete data availability. We employ firm fixed-effects panel regressions to estimate the relationship between EID and CEP. To capture supranational institutional anchoring, we use the European Union (EU) as a salient empirical context characterised by strong and centralised environmental governance. EU presence is operationalised as a binary indicator

denoting whether a firm maintains at least one subsidiary in an EU member state, enabling us to assess whether affiliation with a supranational regulatory regime conditions firms' responses to dispersed environmental institutional environments. To further explore the underlying mechanisms, we distinguish between firms operating in a single EU market and those operating in multiple EU markets by introducing the concept of supranational institutional breadth, which captures the extent of firms' exposure to institutional environments across multiple EU member states.

This study contributes to research at the intersection of institutional diversity, global sustainability, and multilevel governance. First, it challenges the dominant view that cross-national institutional heterogeneity mainly creates barriers, uncertainty, and liability for MNEs (Lundan & Li, 2019; Stahl et al., 2016). We show that, in the environmental domain, environmental institutional diversity (EID) can be performance-enhancing: when environmental performance is evaluated holistically across the MNE, diversity makes weak subsidiaries more visible, heightens legitimacy risk, and induces firms to raise internal environmental baselines. Second, we explain how EID translates into corporate environmental performance by linking institutional theory and internalisation theory. Institutional diversity creates the incentive to respond through stakeholder scrutiny and legitimacy pressures (Kostova & Zaheer, 1999; Kostova et al., 2008), while internalisation provides the organisational capacity to respond through headquarters monitoring, internal rule-setting, and cross-subsidiary transfer of environmental practices (Christmann, 2004; Buckley & Casson, 2010, 2020; Rugman & Verbeke, 2001; Verbeke & Kano, 2016). In doing so, we show that generic institutional measures obscure the domain-specific mechanisms through which environmental institutions shape CEP. Third, we extend research on supranational institutions and multilevel governance by showing that MNE environmental outcomes are jointly conditioned by heterogeneous national institutions, firm-level governance, and supranational institutional anchoring (Pinkse & Kolk, 2012a; Sun et al., 2021; Hartmann et al., 2022a; Kano et al., 2025). Supranational institutions do not merely constrain firms directly; they amplify the governance effects of institutional diversity by increasing visibility and comparability across subsidiaries and by lowering the costs of cross-border coordination.

2. THEORETICAL BACKGROUND

2.1 Theoretical Foundations

International business scholarship increasingly treats institutions as a foundational explanation for why firms differ in strategy and outcomes across countries. The institution-based view argues that firm behaviour is conditioned by the formal and informal "rules of the game" that shape incentives, constraints, and uncertainty in a given setting (North, 1990). Peng (2002) position this institution-based view as a core pillar for understanding international business strategy, alongside industry- and resource-based perspectives (Barney, 1991; Porter, 1998). A key implication in the multinational context is that institutions are inherently cross-border: MNEs must operate under multiple institutional environments and navigate tensions between internal organisational practices and external expectations. A large body of IB research has therefore used institutional theory to explain how MNEs respond to host-country institutional conditions, how they transfer practices across borders, and how subsidiaries balance competing institutional demands (Kostova et al., 2008). Environmental and climate-related issues provide an especially relevant domain for an institutional lens because governance is uneven and often fragmented. Pinkse and Kolk (2012) emphasise that climate change is characterised by institutional failures, including the lack of enforceable global rules and incomplete regional/national frameworks, and that these failures "materialise differently" across countries, creating institutional voids and varied stakeholder expectations across locations. This makes corporate environmental conduct strongly embedded in nonmarket institutions, where legitimacy concerns and institutional pressures can differ across jurisdictions. Finally, contemporary IB work has broadened the institutional lens beyond purely national contexts. Hartmann et al. (2022) argue that supranational institutions form an integral part of the global institutional ecosystem yet have historically been under-theorised in IB; they develop the concept of institutional triality to capture how MNEs can be shaped by multiple national environments and a supranational layer. This broader view supports examining multinational environmental governance as shaped by institutional conditions that extend beyond the nation-state.

Internalisation theory provides a complementary foundation for this study because it explains how MNEs govern cross-border activities under conditions of external market imperfection and institutional heterogeneity. At its core, internalisation theory argues that firms internalise activities when the benefits of coordinating them under common ownership and control exceed the costs of relying on external markets (Buckley & Casson, 1976; Casson, 2016). Applied to the MNE, the theory explains why firms organise knowledge-intensive and strategically important activities across borders through internal hierarchies rather than arm's-

length contracting, and why headquarters-subsidiary as well as subsidiary-subsidiary coordination are central to multinational governance (Buckley, 2009, 2016; Rugman & Verbeke, 2001; Verbeke & Kano, 2016). This perspective is particularly appropriate for analysing the relationship between environmental institutional diversity and corporate environmental performance because EID does not affect firms only through external pressure; it also creates a governance problem inside the multinational network. As environmental regulation becomes more heterogeneous across host countries, MNEs face growing costs from inconsistent environmental conduct across subsidiaries. Internalisation theory suggests that, under such conditions, firms can respond by substituting for uneven external regulation through firm-level environmental baselines, centralised monitoring, standardised compliance routines, and cross-border transfer of environmental practices. In this way, internalisation theory explains the organisational capacity through which MNEs convert environmental institutional diversity into internal standardisation and subsidiary upgrading.

2.2 Corporate Environmental Performance

Corporate environmental performance (CEP) is a multidimensional construct, and scholars highlight the importance of distinguishing among different types of environmental indicators when assessing firms' environmental outcomes (Ilinitch et al., 1998). In this study, we adopt the natural-environment perspective and focus on realised environmental impacts. Early work highlighted the importance of measuring environmental outcomes directly rather than relying on stated intentions (Ilinitch et al., 1998). Building on this insight, King and Lenox (2001) advanced an outcomes-based approach by operationalising environmental performance using objective pollution and emissions indicators. However, because firms' environmental impacts span multiple dimensions, including emissions, resource efficiency, and environmental innovation, recent research increasingly relies on externally evaluated composite indicators that capture broader environmental outcomes. Consistent with this approach, we conceptualise corporate environmental performance as the overall environmental consequences of firms' operations and environmental management activities, measurable through both objective indicators and independent assessments (Claver et al., 2007).

A substantial body of cross-national research demonstrates that CEP is deeply embedded in institutional environments, which influence CEP through three interrelated mechanisms summarised from the literature: incentive structuring, enforcement credibility, and stakeholder visibility. First, institutional arrangements determine the economic incentives

firms face. In countries with well-developed financial markets and strong investor protection, firms are subject to heightened scrutiny from capital markets and institutional investors, who increasingly incorporate environmental risks into valuation decisions. Cross-country evidence suggests that stronger market-supporting institutions are associated with improved ESG and environmental performance, in part because firms anticipate reputational and financial consequences for environmental misconduct (Ioannou & Serafeim, 2012). Similarly, foreign institutional investors may pressure firms to improve environmental outcomes in order to mitigate reputational and regulatory risks, reinforcing sustainability incentives through monitoring and engagement (Ellimäki et al., 2023). Second, formal institutions shape CEP through the credibility and stringency of enforcement. Where environmental regulations are well-defined and consistently enforced under a strong rule-of-law framework, firms face greater costs of non-compliance and stronger incentives to internalise environmental externalities. Research shows that multinational enterprises adjust their environmental strategies in response to such institutional differences, with stronger host-country institutions associated with improved environmental outcomes and greater standardisation of environmental practices (Aguilera-Caracuel et al., 2013; J. Hartmann & Uhlenbruck, 2015). In this sense, enforcement capacity reduces uncertainty and increases the expected penalties of environmental misconduct. Third, formal political institutions affect CEP by shaping transparency, accountability, and public scrutiny. Press freedom, political openness, and policy stability influence how visible corporate environmental behaviour becomes and how effectively stakeholders can mobilise around environmental issues. In more transparent systems, firms face stronger reputational exposure, which can motivate proactive environmental strategies (Kim et al., 2025). Moreover, firms operating across borders must interpret not only formal rules but also the broader institutional expectations embedded in foreign markets; difficulties in recognising and adapting to these expectations can undermine legitimacy and environmental performance (Amer, 2023).

However, despite these advances, prior research overwhelmingly conceptualises institutions as country-level attributes and typically examines their effects either in isolation (e.g., host-country regulation stringency) or through dyadic home–host comparisons. In doing so, it implicitly assumes that firms respond to one dominant institutional environment at a time. This modelling strategy is analytically convenient, but it under-theorises the organisational reality of multinational enterprises (MNEs), which operate simultaneously across multiple jurisdictions characterised by heterogeneous regulatory regimes, enforcement capacities,

political priorities, and normative expectations. Managers in MNEs must coordinate compliance, allocate resources, and integrate environmental practices across this portfolio of institutional contexts, rather than react to a single national setting. Such simultaneous exposure generates institutional diversity, the heterogeneity of institutional environments across an MNE's international footprint (Banalieva & Dhanaraj, 2013; Jackson & Deeg, 2008; Pisani et al., 2018; Verbeke et al., 2014; Zhao et al., 2020). Institutional diversity captures the distribution and variance of regulatory stringency, enforcement credibility, and policy orientations across all host countries in which a firm operates. Two firms may exhibit identical degrees of internationalisation in terms of the number of foreign markets entered, yet face fundamentally different institutional landscapes: one may operate in countries with relatively similar environmental regimes, while another may confront wide dispersion in regulatory stringency and enforcement quality. Related research on institutional distance and environmental standardisation provides valuable insights into how differences between home and host countries influence firms' adaptation and standardisation decisions (Aguilera-Caracuel et al., 2014). However, this literature remains primarily dyadic, focusing on pairwise comparisons rather than the cumulative configuration of institutional exposure. As a result, it risks conflating institutional distance, a relational measure, with the substantive institutional profile of host countries (van Hoorn & Maseland, 2016). Moreover, distance measures typically assume symmetry in cross-national differences (Shenkar, 2001), despite evidence that firms' ability to cope with unfamiliar institutional environments is asymmetric and contingent on prior experience, capabilities, and strategic orientation (Lundan & Li, 2019). These limitations suggest that institutional distance and country-level institutional strength cannot fully capture how multinational firms experience and manage the complexity arising from heterogeneous institutional portfolios.

2.3 Environmental Institutional Diversity and Corporate Environmental Performance

Although scholars widely acknowledge that multinational enterprises (MNEs) operate across heterogeneous institutional environments, prior research differs substantially in how institutional diversity is defined, theorised, and measured. To clarify the construct and situate our contribution, we first distinguish conceptual forms of diversity and then trace how the institutional literature has evolved from country-level and dyadic approaches toward portfolio-level perspectives. At a conceptual level, institutional diversity refers to the heterogeneity of institutional environments across an MNE's international portfolio

(Banalieva & Dhanaraj, 2013; Jackson & Deeg, 2008a; Morgan, 2009; Pisani et al., 2018; Verbeke et al., 2014; Zhao et al., 2020a). Drawing on Harrison and Klein (2007), diversity can take distinct forms with different theoretical implications. Separation-based diversity captures differences along ordered, continuous dimensions, such as regulatory stringency or enforcement intensity, and is typically operationalised through dispersion measures. Variety-based diversity reflects differences in kind, such as distinct institutional regimes or models of capitalism. Disparity-based diversity concerns unequal distributions of resources, power, or attention across units. While IB research frequently invokes the language of "institutional diversity" or "heterogeneity," it often implicitly relies on separation-based operationalisations without explicitly justifying why this form of diversity is theoretically appropriate. In contrast, comparative capitalism scholarship emphasises variety-based institutional configurations (Jackson & Deeg, 2008), highlighting systemic complementarities across labour markets, finance, governance, and inter-firm relations. This conceptual divergence has limited cumulative theory development, as different streams analyse different forms of diversity while drawing generalised conclusions about "institutions."

Early IB research established institutions as fundamental contextual conditions shaping MNE strategy and performance. Within the internalisation tradition, institutions are treated primarily as sources of transaction costs and adaptation challenges affecting governance choices and the recombination of firm-specific advantages (Verbeke et al., 2014). However, this literature largely conceptualises institutions at the country level and operationalises them through dyadic home-host comparisons. Institutional diversity is acknowledged, but it is not theorised as a firm-level structural condition arising from simultaneous exposure to multiple environments. Comparative capitalism scholars deepen the conceptual understanding of institutional heterogeneity by emphasising institutional configurations and internal system complementarities (Jackson & Deeg, 2008a; Morgan, 2009). Yet this configurational perspective, while theoretically rich, remains weakly integrated with performance-oriented IB research because it provides limited operational guidance for large-sample empirical analysis.

A major shift occurs when IB scholars reconceptualise institutional diversity as a portfolio-level phenomenon. Rather than focusing on bilateral institutional distance, this stream emphasises that MNEs are simultaneously exposed to multiple institutional environments and must manage their cumulative effects. Banalieva and Dhanaraj (2013) conceptualise regional institutional diversity as variation across countries within a region and show that greater

diversity increases search and deliberation costs. Zhao et al. (2020) formalise this logic by defining host-country institutional diversity as dispersion across an MNE's host-country portfolio and theorising a benefit–cost trade-off: institutional diversity enhances flexibility and learning up to a point but generates coordination and complexity costs beyond that threshold. Similarly, Wu and Park (2019) demonstrate that international institutional complexity influences innovation performance, while Arregle et al. (2016) show that institutional diversity shapes subsequent FDI configuration decisions. These studies make two important advances: they treat institutional diversity as a firm-level structural attribute, and they demonstrate systematic strategic and performance implications. However, despite these advances, much of the literature still conceptualises institutions as country-level attributes and models their effects either independently or through dyadic comparisons. This approach implicitly assumes that firms respond to one institutional environment at a time. It under-theorises the organisational reality of MNEs, which must coordinate activities across jurisdictions characterised by distinct regulatory regimes, enforcement practices, and policy orientations. Institutional distance measures, while useful, remain dyadic and risk conflating relational differences with the substantive institutional profiles of host countries (van Hoorn & Maseland, 2016). Moreover, distance measures assume symmetry in cross-national differences (Shenkar, 2001), despite evidence that firms' ability to cope with unfamiliar institutions is asymmetric and capability-dependent (Lundan & Li, 2019). Dau et al., (2022) synthesise and critique this body of work, explicitly calling for greater attention to institutional heterogeneity, multiplicity, and dimensionality across organisational levels and institutional domains. They emphasise that firms experience institutional diversity as simultaneous exposure to heterogeneous environments, not as isolated bilateral differences. This synthesis legitimises portfolio-level approaches but also highlights persistent limitations, including conceptual ambiguity and reliance on decontextualised institutional proxies. Building on these insights, we conceptualise institutional diversity as the heterogeneity of institutional environments to which an MNE is simultaneously exposed through its international operations. Within this framework, we focus empirically on separation-based diversity, as this form is theoretically appropriate when institutions vary along ordered dimensions and when mechanisms of interest involve coordination costs, learning opportunities, and capability development. Importantly, this choice does not imply that variety-based or disparity-based diversity is unimportant; rather, it reflects analytical precision aligned with dominant IB performance theories.

We further introduce environmental institutional diversity (EID), defined as variation in institutions governing environmental protection and sustainability across the countries in which an MNE operates. Institutional diversity is inherently domain-specific: the institutional dimensions that matter depend on the focal outcome and the mechanisms theorised. Prior IB scholarship cautions against treating institutions "thinly" through highly aggregated indicators that obscure domain-specific mechanisms (Jackson & Deeg, 2008). Lundan and Li (2019) similarly emphasise that institutional diversity is multidimensional and that meaningful theorising requires attention to which institutional features vary and why they matter for particular strategic tasks. Although institutional diversity has traditionally been framed as a source of uncertainty and liability (Stahl et al., 2016), its potential advantages have received comparatively less attention. Rather than minimising heterogeneity, MNEs may leverage diverse institutional exposure as a source of learning and strategic flexibility. Emerging evidence supports this portfolio view: institutional diversity shapes geographic configuration decisions (Arregle et al., 2016), innovation outcomes (Wu & Park, 2019), and performance persistence (Zhao et al., 2020). Yet this literature typically relies on broad, generic institutional indicators and rarely examines domain-specific institutional diversity in relation to specific performance outcomes. Understanding environmental institutional diversity is, therefore, essential for advancing theory beyond country-centric explanations toward a more realistic account of how MNEs experience and manage heterogeneous institutional environments in pursuing environmental performance.

2.4 Supranational Institutional Anchoring

IB research increasingly recognises that institutions shaping firm behaviour extend beyond the nation-state. Rather than treating national institutions as self-contained boundary conditions, recent scholarship emphasises that MNEs operate within multilayered governance systems in which supranational arrangements interact with home- and host-country institutions. Sun et al. (2021) show that MNEs navigate institutional complexity not only across countries but also within supranational and transnational issue arenas that structure nonmarket strategy and corporate responsibility. Hartmann et al. (2022) formalise this perspective by conceptualising supranational institutions as a distinct layer in the MNE's institutional environment that can condition, complement, or reshape national institutional effects. This multilevel lens is particularly salient in sustainability domains, where environmental challenges require coordination across interacting institutional systems rather

than reliance on single-country regulatory frameworks (Kano et al., 2025; Pinkse & Kolk, 2012b). Building on this perspective, we introduce supranational institutional anchoring (SIA) as a mechanism through which supranational governance structures shape firm behaviour.

Institutional anchoring refers to the stabilisation and legitimation of organisational practices through linkage to recognised institutional reference points, thereby reducing resistance and contestation (Malhotra et al., 2021). Extending this logic to the multilevel institutional context of IB, we define supranational institutional anchoring as a binary condition reflecting whether a firm is embedded within supranational governance frameworks that establish and enforce shared rules, norms, and standards across jurisdictions. Supranational institutions constitute a distinct layer in the MNE's institutional environment and can condition or reshape national institutional effects (Hartmann et al., 2022). In environmental governance, such arrangements include regional regulatory systems and transnational agreements that structure cross-border expectations (Pinkse & Kolk, 2012b). While soft-law instruments provide flexible coordination under institutional heterogeneity (Abbott & Snidal, 2000), more institutionalised global or regional regulatory systems can supplement fragmented national regimes by supplying shared governance frameworks (Mattli & Woods, 2009; Djelic & Sahlin, 2006).

Despite explicit calls to examine multilevel institutional complexity (Hartmann et al., 2022a; Sun et al., 2021), existing research largely treats supranational institutions as contextual background conditions rather than theorising how firms' anchoring and degree of anchoring in supranational frameworks condition the performance implications of cross-national institutional diversity. This omission is particularly salient in the climate domain, where governance remains fragmented and institutional failures persist (Kano et al., 2025; Pinkse & Kolk, 2012b). Consequently, we lack a systematic understanding of whether, and under what conditions, supranational institutional anchoring reshapes the relationship between EID and CEP.

2.4 Conceptual Framework

Building on the institution-based view and internalisation theory, we develop a framework linking EID to CEP, with supranational institutional anchoring (SIA) as a moderating condition. Institutional theory explains why EID generates stronger external pressures for legitimacy, compliance, and cross-border responsiveness, while internalisation theory explains how MNEs possess the internal governance capacity to respond through firm-

subsidiary coordination, subsidiary-subsidiary sharing, and cross-border standardisation. As environmental institutional diversity increases, these external and internal drivers jointly encourage MNEs to raise internal minimum environmental standards, reduce subsidiary-level performance variance, and improve overall corporate environmental performance.

Supranational institutional anchoring amplifies this process by simultaneously increasing external pressure to address environmental performance gaps and improving firms' internal capacity to benchmark, monitor, coordinate, and diffuse environmental practices across subsidiaries. Under stronger supranational anchoring, MNEs are therefore better able to translate environmental institutional diversity into effective internal standardisation and, ultimately, higher corporate environmental performance. As firms move from initial anchoring to wider expansion within the same supranational regime, environmental governance becomes increasingly routinised, and coordination burdens intensify, reducing the extent to which additional breadth further enhances the governance benefits of EID. Figure 1 illustrates this framework.

[Figure 1. Conceptual Model]

3. HYPOTHESES DEVELOPMENT

3.1 Environmental Institutional Diversity and Corporate Environmental Performance

Environmental institutional diversity (EID) can enhance corporate environmental performance by increasing MNEs' incentives to reduce environmental performance variance across subsidiaries through firm-level standardisation. As EID rises, subsidiaries operate under more heterogeneous environmental regulatory regimes, with greater dispersion in regulatory stringency, enforcement intensity, and compliance expectations. This variation increases the likelihood that some subsidiaries will perform to weaker local standards, creating uneven environmental outcomes within the firm. Such unevenness matters because environmental performance is increasingly evaluated at the corporate rather than only at the subsidiary level (Christmann, 2004; Cuervo-Cazurra et al., 2021; Haack et al., 2014; Surroca et al., 2013). Under conditions of high EID, strong performance in some jurisdictions does not offset legitimacy and reputational risks created by weaker performance elsewhere. What matters for firm-level evaluation is not maximising environmental performance everywhere,

but reducing exposure to underperforming outliers that can undermine overall corporate credibility.

From an institutional theory perspective, the key external driver is growing stakeholder pressure for legitimacy under conditions of cross-national institutional heterogeneity. Transnational stakeholders, including investors, NGOs, supply-chain partners, and the media, increasingly assess MNEs holistically across their international operations rather than treating each subsidiary as institutionally isolated (Haack et al., 2014; Surroca et al., 2013). As EID increases, the gap between subsidiaries operating under stringent regimes and those embedded in weaker regulatory contexts becomes more visible, intensifying legitimacy challenges for the firm as a whole. In such contexts, poor environmental conduct in weakly regulated locations can trigger external scrutiny and damage corporate legitimacy even when other subsidiaries perform strongly. Accordingly, MNEs face growing pressure to demonstrate credible environmental compliance across borders and to engage in legitimacy building by reducing conspicuous performance gaps within the multinational network. This does not imply a full race-to-the-top in which all subsidiaries adopt the most stringent regulatory standard in the portfolio (Bradford, 2020; Vogel, 1995), because universal upgrading would often be prohibitively costly and organisationally unrealistic. Nor does simple regulatory convergence or average-level harmonisation adequately resolve legitimacy risk, since middling standards may still leave poorly performing subsidiaries exposed (Drezner, 2001; Porter & Linde, 1995). Instead, EID encourages firms to raise internal minimum standards above the weakest host-country requirements and to strengthen monitoring and reporting systems across subsidiaries in order to upgrade underperforming outliers and protect firm-wide legitimacy (Christmann, 2004; Christmann & Taylor, 2001). In addition, exposure to multiple regulatory environments enables cross-border learning, as firms observe, interpret, and selectively diffuse environmental expectations and practices from more demanding contexts to weaker ones.

From an internalisation theory perspective, the main internal driver is the MNE's ability to respond to EID through hierarchical governance, cross-border coordination, and intra-firm transfer of practices. Unlike purely domestic firms, which operate within a single regulatory regime and are largely constrained by domestic enforcement conditions, MNEs span multiple institutional environments and possess governance structures that enable them to coordinate activities across borders (Buckley & Casson, 2020). When EID increases the diversity of

environmental regulatory stringency across subsidiaries, MNEs face higher organisational costs from inconsistent environmental conduct, including greater governance complexity, legitimacy management challenges, and coordination burdens (Jackson & Deeg, 2008b; Kostova et al., 2008; Kostova & Zaheer, 1999). Yet MNEs are not passive recipients of such diversity. Through internalisation, they can substitute for uneven national enforcement by imposing firm-level environmental baselines that apply across jurisdictions (Buckley & Casson, 2010; Rugman & Verbeke, 2001; Verbeke & Kano, 2016). This occurs through headquarters-subsidiary governance, centralised monitoring, internal rule-setting, auditing, and reporting systems, as well as through subsidiary-subsidiary sharing of routines and practices developed in more stringent institutional contexts. Such internal governance gives MNEs a distinctive capacity to coordinate cross-border activities, diffuse environmental knowledge within the firm, and reduce performance variance across subsidiaries. As EID increases, the expected costs of inconsistency rise, reinforcing incentives to strengthen internal governance and elevate the internal environmental performance floor. This governance capacity distinguishes MNEs from purely domestic firms and enables institutional dispersion to translate into firm-level environmental upgrading. Thus, we propose that:

Hypothesis 1. Greater environmental institutional diversity has a positive effect on MNEs' CEP.

3.2 The Moderating Role of Supranational Institutional Anchoring

Supranational institutional anchoring moderates the EID-CEP relationship by providing a structured institutional framework that clarifies environmental expectations and strengthens both the external legitimacy pressures and the internal organisational capacity for firms to align environmental practices across their international operations (Damro, 2012; S. Hartmann et al., 2022b; Sandholtz et al., 1998). The first moderating mechanism operates through stronger stakeholder pressure, legitimacy demands, and compliance expectations. Supranational institutional anchoring increases the costs of uneven environmental performance within the multinational enterprise by embedding subsidiaries within a broader transnational governance framework. The supranational institutions, such as the European Union, have relatively stringent environmental directives, harmonised compliance procedures, and common monitoring and disclosure requirements, establishing widely recognised benchmarks for environmental governance. These supranational institutions increase the visibility, comparability, and public accountability of firms' environmental practices across

countries, making it easier for regulators, investors, NGOs, and civil society actors to evaluate environmental conduct at the level of the firm rather than the individual subsidiary. Because stakeholders often assess MNEs holistically, underperformance in any single subsidiary becomes more salient and more likely to be interpreted as a failure of firm-level governance rather than as an outcome attributable solely to local institutional constraints (Kostova & Zaheer, 1999; Kostova et al., 2008; Jackson & Deeg, 2008b). In this way, supranational institutional anchoring intensifies legitimacy risks associated with lagging subsidiaries and strengthens firms' incentives to engage in legitimacy building by raising the environmental performance floor across their international networks. It therefore reinforces the external mechanism linking EID to CEP: when supranational institutional anchoring is stronger, institutional diversity is more likely to trigger firm-wide compliance efforts and upgrading of underperforming units.

The second moderating mechanism operates through stronger cross-border governance, firm-subsidiary coordination, and intra-firm transfer of practices. Supranational institutional anchoring not only increases pressure to address environmental performance gaps but also improves MNEs' ability to do so. Harmonised regulatory frameworks, common reporting templates, and shared compliance architectures make it easier for headquarters to compare subsidiaries, benchmark environmental performance, identify weak performers, and coordinate corrective action across borders. Shared supranational institutional templates also facilitate the transfer and diffusion of environmental management routines among subsidiaries, including learning from units embedded in more advanced regulatory settings and the spread of practices across the internal network (Jackson & Deeg, 2008b; Lundan & Li, 2019; Zollo & Winter, 2002). This reduces the coordination and governance costs associated with managing diverse environmental regulations and enhances the effectiveness of internal standardisation. In other words, supranational institutional anchoring strengthens the internalisation capacity of MNEs by making cross-border activities more governable and subsidiary–subsidiary sharing more feasible. As a result, MNEs can more effectively substitute for uneven national enforcement through firm-level rule-setting, monitoring, and environmental governance.

This moderating effect is most apparent at the stage of initial supranational anchoring. Once a firm enters a supranational institutional order, it becomes exposed to common environmental expectations and broader transnational scrutiny, which reinforce the governance pressures

generated by environmental institutional diversity. Even limited anchoring can therefore strengthen the positive effect of EID on CEP by making environmental inconsistencies more visible and by providing firms with shared institutional templates for cross-border coordination. Thus, we propose that:

Hypothesis 2 (H2). Supranational institutional anchoring positively moderates the relationship between EID and MNEs' CEP.

However, the implications of supranational anchoring become more nuanced as firms deepen their embeddedness across multiple markets within the same supranational regime. Although subsidiaries remain located within a common supranational framework, firms must still manage variation in how supranational rules are transposed, interpreted, and enforced across member states (Börzel, 2000; Falkner & Jaspers, 2012; Knill & Lenschow, 1998). Repeated exposure to these supranationally embedded but administratively differentiated contexts encourages firms to codify environmental governance into centralised compliance systems, formalised monitoring infrastructures, and standardised reporting routines (Argote & Miron-Spektor, 2011; Christmann, 2004; Delmas & Toffel, 2008; Levitt & March, 1988; Zollo & Winter, 2002). Over time, environmental management becomes increasingly routinised within the organisation.

As this routinisation proceeds, the marginal governance benefits generated by EID are likely to diminish. When internal compliance templates and environmental monitoring systems are already well developed, additional diversity within the same supranational institutional order is more likely to be absorbed by existing governance routines than to stimulate further upgrading. At the same time, broader supranational embeddedness can increase internal coordination demands. Managing multiple regulatory interfaces, national administrative practices, and subsidiary-level compliance relationships within the same supranational framework reallocates managerial attention toward maintaining harmonised systems of control, potentially crowding out experimentation and incremental improvement (Kostova et al., 2008; Meyer et al., 2011; Ocasio, 1997). Thus, while supranational anchoring initially strengthens the positive EID-CEP relationship, broader embeddedness within the same supranational order may yield diminishing marginal returns. Accordingly, we propose:

Hypothesis 3 (H3). Supranational institutional breadth does not significantly moderate the relationship between EID and CEP.

4. METHOD (1761)

4.1 Sample and Data

We construct an unbalanced firm-year panel of U.S.-headquartered MNEs covering 2010-2023, consistent with the availability of data from the OECD Climate Actions and Policies Measurement Framework. Focusing on U.S.-headquartered firms provides a common home-country institutional baseline while allowing substantial variation in foreign subsidiary portfolios and environmental institutional diversity across host countries. Our initial sample consists of U.S.-headquartered firms covered in LSEG Refinitiv Workspace and classified into five SIC sectors: Manufacturing; Transportation, Communication, Electric, Gas, and Sanitary Services; Construction; Mining; and Agriculture, Forestry, and Fishing. We exclude firms in retail trade, finance, insurance, real estate, services, public administration, and wholesale trade. We focus on operationally intensive sectors because environmental performance in these industries is more directly linked to production activities and physical emissions, improving comparability in our CEP measure. We then match these firms to their overseas subsidiaries in Orbis using firm identifiers. Because our key independent variable captures cross-border host-country exposure, we retain only firms with at least one foreign subsidiary and restrict subsidiaries to corporate entities. After aggregating subsidiary-level information to the headquarters level and retaining firm-years with complete data, the final sample comprises 344 firms and 2,528 observations.

4.2 Variables and Measures

4.2.1 Dependent variable: corporate environmental performance

We operationalise CEP using the Environmental Pillar Score from the LSEG Refinitiv Workspace because it provides a widely used, firm-year measure of environmental performance grounded in firms' disclosed policies, practices, and outcomes. The Refinitiv environmental pillar is particularly well suited to our setting because it captures multiple environmentally material dimensions, such as emissions, resource use, and environmental innovation–related performance, that align with our theoretical focus on how cross-national environmental governance exposure shapes firms' internal environmental management and outcomes. In addition, it has become a common data source in international business and strategy research examining environmental performance and institutional context, supporting their construct validity and comparability across multinational samples (e.g., Symeou et al., 2017; Hartmann & Uhlenbruck, 2015; Griffin et al., 2021). Recent studies also directly rely on it to capture environmental performance in related empirical designs, further validating this measure's

suitability for panel analyses of firm environmental outcomes (e.g., Ellimäki et al., 2023; Zhang et al., 2023; Zhang et al., 2024; Ahmadova et al., 2022; Shoham et al., 2024).

4.2.2 Independent variable: Environmental institutional diversity

We measure EID as the asset-weighted diversity of host-country environmental policy frameworks across a firm's foreign subsidiary portfolio. We operationalise country-level environmental policy stringency using CAPMF's sectoral policy component (LEV1_SEC), focusing on market-based and non-market-based instruments applied to core emitting sectors. We prioritise sectoral policies over cross-sectoral policies because sectoral instruments represent the most direct, enforceable, and comparable sources of operational environmental constraints faced by firms (e.g., carbon pricing, taxes/charges, and performance standards, bans, and mandates). This instrument-based classification also maps closely onto our theoretical construct of environmental institutional diversity as heterogeneity in policy instrument logics, market incentives versus regulatory/command-and-control approaches, through which MNEs must learn and adapt compliance and abatement routines across locations. In contrast, cross-sectoral policies largely capture broader national policy architecture (e.g., economy-wide targets, governance arrangements, and public R&D categories), which can be more heterogeneous in legal force and less directly tied to firm-level operational compliance, thereby introducing construct ambiguity for a dispersion-based measure of institutional exposure (OECD, 2025).

To construct each firm's portfolio of foreign subsidiaries, we use Bureau van Dijk's Orbis database, which reports ownership information (including the "global ultimate owner") that enables researchers to link multinational parents and their cross-border affiliates and identify ownership ties (Cravino& Levchenko, 2017; Tørsløv et al., 2023). We extract each subsidiary's country ISO code and identifiers and collect subsidiary-level financial information from Orbis. This Orbis-based ownership-linking approach is commonly used in international economics and related fields to construct multinational affiliate networks and characterise foreign affiliate presence across host countries, while recognising that Orbis coverage can be incomplete in some jurisdictions because it relies on public registry information.

We adopt asset-weighting to reflect the firm's relative economic dependence on each institutional environment by scaling exposure to environmental policy conditions by the share of foreign subsidiary assets located in that country. Larger subsidiaries imply greater regulatory

compliance obligations, higher sunk costs, and stronger institutional pressures, particularly in the environmental domain, where policies directly affect physical production assets. Weighting subsidiary exposure by assets avoids overstating the influence of economically marginal operations and better captures the intensity of firms' host-country commitments. By aligning institutional exposure with the scale of operational engagement, this approach reflects the depth of resource commitment emphasised in internationalisation and subsidiary-level research (e.g. Delios & Beamish, 1999; Johanson & Vahlne, 1977). Compared with unweighted country counts or simple averages, this approach provides a more accurate representation of the environmental institutional complexity actually experienced by the firm.

$$w_{ict} = \frac{foreign\ subsidiary\ assets\ in\ country\ c}{\sum_{ict} foreign\ subsidiary\ assets}$$

For each firm i in year t, we first compute the asset-weighted mean exposure to environmental policies across host countries:

$$\mu_{it} = \sum_{c} w_{ict} \,.\, EPS_{ct}$$

Where w_{ict} represents the proportion of the firm's total foreign subsidiary assets located in country c denotes the country-year environmental policy indicator derived from CAPMF. Environmental institutional diversity is then calculated as the weighted standard deviation of host-country policy conditions around the firm's portfolio mean:

$$Environmental\ Institutional\ Diversity_{it} = \sqrt{\sum_{c} w_{ict} \cdot (EPS_{ct} - \mu_{it})^2}$$

This formulation captures the extent to which a firm's foreign operations are distributed across heterogeneous environmental policy environments, consistent with portfolio-based approaches in the international strategy literature. We summarise a firm's host-country policy environment as an asset-weighted portfolio mean and capture environmental institutional diversity as the dispersion of host-country policy conditions around that mean (e.g. Belderbos et al., 2020; Goerzen & Beamish, 2003). This formulation reflects that greater heterogeneity across operating environments increases the complexity of managing foreign operations (Wu & Park, 2019).

4.2.3 Moderators: Supranational Institutional Anchoring

The European Union represents one of the most institutionalised and legally embedded supranational environmental governance systems. Unlike global climate governance arrangements centred on the United Nations (UN), which rely heavily on agenda-setting, coordination, and nationally determined implementation (Abbott & Snidal, 2021; Keohane & Victor, 2011), the European Union (EU) represents a more institutionalised supranational polity with delegated authority and comparatively stronger legalisation. EU environmental governance operates through binding directives and regulations that are promulgated at the supranational level and implemented across member states within a structured multilevel system (Sweet & Sandholtz, 1997; Börzel, 2000). Although national transposition and enforcement vary, EU institutions possess formal mechanisms for monitoring compliance and adjudicating non-compliance, including judicial review and infringement procedures (Falkner & Jaspers, 2012). Moreover, scholarship on EU regulatory power highlights how EU rules shape corporate practices not only within member states but also through market-access incentives and rule externalisation dynamics (Damro, 2012). These features distinguish the EU from UN-centred climate governance, where commitments are largely nationally determined, and enforcement is decentralised. Consequently, EU presence is more likely to embed standardised and relatively stringent environmental compliance routines within firms, making it a theoretically appropriate operationalisation of supranational institutional anchoring in this study. The EU provides a powerful supranational regulatory template characterised by clear environmental principles, standardised expectations, and relatively strong enforcement signals. This supranational template does not merely add another regulatory layer; it offers a higher-order reference point against which heterogeneous national environmental demands can be evaluated.

We operationalise supranational institutional anchoring using a binary indicator of EU presence, coded as 1 if the firm maintains at least one foreign subsidiary in a European Union (EU) member state in year t, and 0 otherwise. This measure captures the threshold condition under which a firm becomes embedded in the EU's supranational governance framework, including environmental directives, emissions trading rules, and reporting standards. Prior research highlights that supranational institutions constitute a governance layer beyond the nation-state and can shape MNE behaviour through region-wide rule-making, as exemplified by the European Union (Flores et al., 2013; S. Hartmann et al., 2022). In the environmental domain,

EU-wide instruments such as the EU Emissions Trading System have been shown to influence firms' emissions and economic outcomes (Dechezleprêtre et al., 2023). Moreover, the EU's regulatory influence can extend beyond its borders, encouraging firms to align with EU standards to maintain market access (Young, 2015; European Parliament, 2024).

To examine supranational institutional breadth, we construct a multiple-EU-markets indicator coded as 1 if a firm operates in two or more EU member states in a given year and 0 otherwise. This measure captures the transition from initial supranational anchoring to broader engagement within the EU institutional space. All indicators are time-varying and updated annually to reflect changes in firms' EU geographic portfolios.

4.2.4 Control Variables

First, we control for financial performance using the return on assets (ROA). Prior research suggests that environmental strategies and environmental performance can be intertwined with corporate financial performance, both because environmental improvements may affect profitability and because profitable firms may have greater slack resources to invest in environmental upgrading, making ROA an important baseline control when isolating institutional effects (Aguilera-Caracuel et al., 2012; Ahmadova et al., 2023; Hart & Ahuja, 1996). Second, we control for firm age to account for systematic differences associated with organisational maturity (e.g., accumulated experience, established routines, and inertia) that may influence both the ability and incentives to pursue sustained environmental improvements (e.g. Arora & De, 2020). Third, we control for firm size (natural logarithm of total market value) (Black & Kim, 2012; Crane & Koch, 2025; Dang et al., 2018; KNEZ & READY, 1997). Larger firms tend to be more visible to external stakeholders, face greater scrutiny, and typically possess more resources and managerial capacity to implement environmental initiatives, which can systematically shape environmental strategies and outcomes (Ahmadova et al., 2023; Aragón-Correa et al., 2016; Gómez-Bolaños et al., 2020; J. Hartmann & Uhlenbruck, 2015). Finally, we include R&D intensity (R&D expenditures divided by sales), as innovation capability is closely associated with eco-innovation, cleaner production processes, and improved environmental performance (e.g. Alam et al., 2022, 2019; Marano et al., 2017; McWilliams & Siegel, 2001). We summarise all variables, their definitions, measurements and data sources in Table 1.

4.3 Statistical Analysis Method

We estimate OLS regressions using a fixed-effects estimator. This approach is widely used in empirical environmental and climate research to mitigate endogeneity concerns arising from unobserved heterogeneity by leveraging sub-industry variation over time and controlling for common time shocks via year fixed effects (Chatterji & Toffel, 2010; Luo & Tang, 2023; Martinsson et al., 2024). Finally, we include sub-industry-by-year fixed effects to net out time-varying industry forces, such as shifts in technology, regulation, and competitive dynamics, that may affect both firms' environmental performance (e.g. Ellimäki et al., 2021).

4.3.1 Baseline specification

To test the main effect (H1), we estimate:

$$CEP_{it} = \beta_1 EID_{i,t-1} + \gamma' \mathrm{X}_{i,t-1} + \delta_{t-1} + \theta_{s\times t-1} + \varepsilon_{it-1}$$

Where $\mathrm{CEP_{it}}$ is corporate environmental performance for firm i in year t; $EID_{i,t}$ is environmental institutional diversity across the firm's host-country footprint; $\mathrm{X}_{i,t}$ is a vector of firm controls (e.g., size, age, profitability, R&D intensity); δ_t are year fixed effects; $\theta_{s\times t}$ are sub-industry-by-year fixed effects to account for time-varying industry forces.

4.3.2 Moderation models

To examine how supranational institutional anchoring and breadth condition the EID-CEP relationship, we estimate two interaction models. H2: EU presence. We test whether the EID-CEP relationship differs between firm-years with and without EU presence by estimating:

$$CEP_{it} = \beta_1 EID_{i,t-1} + \beta_2\, EU\_Pres_{i,t-1} + \beta_3 (EID_{i,t-1} \times EU\_Pres_{i,t-1}) + \gamma' \mathrm{X}_{i,t-1} + \delta_{t-1} + \theta_{s\times t-1} + \varepsilon_{it-1}$$

H3: EU breadth. We test whether broader supranational institutional breadth conditions the EID-CEP relationship by estimating:

$$CEP_{it} = \beta_1 EID_{i,t-1} + \beta_2\, EU\_Breadth_{i,t-1} + \beta_3 \left(EID_{i,t-1} \times EU_{Breadth_{i,t-1}}\right) + \gamma' \mathrm{X}_{i,t-1} + \delta_{t-1} + \theta_{s\times t-1} + \varepsilon_{it-1}$$

All models use cluster-robust standard errors at the firm level to address serial correlation and heteroskedasticity within firms across years, common concerns in firm-year panel data. Our

theoretical framework focuses on cross-firm differences rather than within-firm changes over time, which motivates the use of industry fixed effects instead of firm fixed effects. This choice is appropriate because our key explanatory variable, environmental institutional diversity (EID), is structurally persistent. EID reflects the diversity of environmental regulatory regimes across a firm's host-country portfolio, which is largely determined by firms' international expansion patterns and the regulatory stringency of host countries, both of which evolve gradually. Consistent with this expectation, panel decomposition shows that within-firm variation in EID is limited (within SD = 0.116) relative to between-firm variation (between SD = 0.170). Because firm fixed effects rely solely on within-firm variation, including them would absorb much of the cross-sectional heterogeneity central to our theory. Prior studies similarly note that when explanatory variables change slowly over time, firm fixed-effects estimates may rely on small temporal fluctuations and introduce noise (Hall et al., 2005; Noel & Schankerman, 2013). Accordingly, research examining persistent firm characteristics often adopts industry fixed effects to preserve cross-firm variation (Campello & Gao, 2017; Dhaliwal et al., 2016; Zhong et al., 2021). To address potential distortion from extreme observations, we winsorise selected continuous variables at the 1st and 99th percentiles. Specifically, return on assets (ROA), R&D intensity (RDS), and the environmental institutional diversity measures (ID_TA, ID_Sales, and ID_Employees) exhibit skewed distributions characteristic of financial ratios and dispersion measures. Winsorisation limits the influence of extreme tail values while retaining the full sample and preserving meaningful variation. Consistent with established practice in international business and strategy research, we do not winsorise dummy variables or variables with approximately symmetric distributions (e.g., firm size and firm age). All substantive results remain robust to alternative trimming thresholds and to specifications using non-winsorised variables.

5. RESULTS

5.1 Baseline and Moderating Test

Table 5 reports the baseline and moderating results. Model (1) presents the empty specification, including only fixed effects. Model (2) introduces the main independent variable, lagged environmental institutional diversity (L.EID_TA). The coefficient on L. EID_TA is positive and statistically significant ($\beta = 10.10$, $p < 0.05$), indicating that greater exposure to heterogeneous environmental institutional environments is associated with higher subsequent environmental performance (LESG_Environmental). The positive association is

economically meaningful and robust to the inclusion of firm-level controls and fixed effects, consistent with the argument that environmental institutional diversity generates governance-enhancing learning and internal standardisation benefits. Thus, this finding supports H1.

Models (3)-(5) examine whether supranational institutional anchoring within the European Union moderates the relationship between EID and CEP. Model (3) introduces EU presence (L.EUNUM_D) and its interaction with L. EID_TA. The interaction term is positive and statistically significant ($\beta = 20.113$, $p < 0.05$), indicating that the positive effect of EID on CEP is amplified for firms with EU presence. This suggests that supranational institutional anchoring does not substitute for diversity-induced governance benefits; rather, EU exposure may strengthen firms' ability to translate institutional diversity into improved environmental outcomes. One possible explanation is that EU regulatory harmonisation provides a structured compliance framework that enhances firms' capacity to internalise diverse regulatory signals effectively, thereby reinforcing the governance benefits of environmental institutional diversity. Model (4) further distinguishes firms operating in two EU markets (L.EUNUM_2) and tests whether limited EU breadth alters the EID-CEP relationship. Neither the direct effect nor the interaction term is statistically significant, suggesting that operating in two EU countries does not materially change the marginal effect of environmental institutional diversity on environmental performance. Model (5) examines firms operating in multiple EU markets (L.EUNUM_M). Again, the interaction term between L.EID_TA and extensive EU presence is not statistically significant, indicating that broader EU market coverage does not systematically strengthen or weaken the diversity–performance relationship beyond the general EU presence effect captured in Model (3). In Model (6), we use a continuous variable that is the number of distinct EU markets the firm enters to further investigate the relationship, which is also not significant. Taken together, the results suggest that supranational institutional anchoring matters primarily at the extensive margin, whether firms are exposed to the EU institutional framework, rather than at the intensive margin measured by the number of EU markets served. EU presence appears to enhance firms' ability to leverage environmental institutional diversity, whereas incremental expansion within the EU does not generate additional moderating effects.

5.2 Endogeneity Test

To rigorously address potential endogeneity concerns, including reverse causality, omitted variables, and dynamic persistence, we implement both two-stage least squares (2SLS)

(Wooldridge, 2010) and two-step system GMM estimations and present their results in Tables 6 and 7. In the two-stage least squares (2SLS) estimation, we instrument environmental institutional diversity (EID) using higher-order deviations constructed following the identification strategy proposed by Lewbel (1997) . Specifically, IV1 captures the cube of the deviation of EID from the mean level within the same state, while IV2 captures the cube of the deviation of EID from the mean level within the same state–subindustry. These instruments exploit higher-moment conditions derived from the distribution of EID to generate exogenous variation. The first-stage results confirm the relevance of the instruments. In Model (1), the coefficient on L.IV1 is positive and highly significant ($\beta = 6.045$, $p < 0.01$), indicating that the higher-order deviation of EID relative to the state mean strongly predicts the endogenous regressor L.ID_TA. Similarly, Model (3) shows that L.IV2 is also strongly associated with L.EID_TA ($\beta = 5.617$, $p < 0.01$). When both instruments are included simultaneously (Model (5)), L.IV1 remains positive and significant ($\beta = 6.816$, $p < 0.01$). Consistent with these findings, the Kleibergen-Paap rk LM statistics reject the null hypothesis of underidentification, confirming that the instruments are relevant. Moreover, the Kleibergen-Paap Wald rk F statistics are substantially above the conventional threshold of 10 (100.454, 49.512, and 69.210 across specifications), suggesting that weak instrument bias is unlikely to be a concern (Cragg & Donald, 1993; Kleibergen & Paap, 2006; Stock & Yogo, 2005). Turning to the second stage, the instrumented coefficient on L.EID_TA remains positive across all specifications but is not statistically significant. While the direction of the effect is consistent with the baseline results, the lack of statistical significance suggests that the relationship between environmental institutional diversity and corporate environmental performance may be sensitive to endogeneity corrections. Importantly, the Hansen J test fails to reject the null hypothesis of instrument validity in the specification including both instruments ($p = 0.558$), supporting the exogeneity of the combined instrument set.

We further estimate a two-step system GMM model to account for the dynamic nature of environmental performance and unobserved firm heterogeneity (Arellano & Bond, 1991). The Arellano–Bond tests indicate the presence of first-order serial correlation (AR(1), $p < 0.01$) but no second-order serial correlation (AR(2), $p = 0.718$), suggesting that the lagged instruments are valid. The Hansen test of overidentifying restrictions does not reject the null hypothesis of instrument validity ($p = 0.068$). Together, these diagnostics indicate that the dynamic panel GMM specification is appropriately specified and the instrument set is valid.

The combined evidence from 2SLS and dynamic panel estimations suggests that the main findings are unlikely to be driven by endogeneity.

5.3 Robustness Check

To ensure the robustness of the baseline findings, several alternative specifications are implemented and summarised in Table 8. First, in Models (1) and (2), we replace the asset-weighted measure of the independent variable with sales-weighted and employee-weighted measures, respectively. The estimated coefficients remain positive and statistically significant, indicating that the main results are not sensitive to the weighting scheme used to construct the key explanatory variable. Second, in Model (3), we employ an alternative dependent variable by using the Environmental Pillar Score Grade from the LSEG Refinitiv database. While our baseline specification relies on the continuous Environmental Pillar Score, the grade measure reflects Refinitiv's categorical assessment of firms' relative environmental standing. To facilitate regression analysis, we convert the letter grades into a 12-point ordinal scale ranging from D-(1) to A+(12), preserving the ordered structure of the rating system. Third, Model (4) re-estimates the baseline specification after winsorising at the 5% level (instead of 1%), and the main coefficient remains stable in both magnitude and significance, alleviating concerns about the influence of outliers. Finally, Model (5) introduces a two-year lag of the independent variables, and Model (6) uses no-lagged independent variables (compared to the one-year lag in the baseline model). The results continue to hold, supporting the temporal robustness of the findings. Overall, these additional tests confirm that the baseline conclusions are not driven by alternative variable constructions, measurement choices, outlier treatment, or lag structure.

5.4 Supplementary Test

To further unpack the mechanism underlying the effect of environmental institutional diversity (EID), we disaggregate corporate environmental performance into its core dimensions: emissions reduction (LESG_Emissions), resource use efficiency (LESG_RUS), and environmental innovation (LESG_EIS). The results in Table 9 show that EID is positively and significantly associated with emissions performance ($\beta = 12.555$, $p < 0.05$) and resource use performance ($\beta = 12.766$, $p < 0.05$), but not with environmental innovation.

6. DISCUSSION AND CONCLUSION

6.1 Findings and Theoretical Contributions

First, we contribute to research on institutional diversity and institutional complexity in IB by shifting attention from average national institutional conditions and dyadic institutional distance to the firm-level configuration of environmental institutions across the multinational portfolio. Prior IB research has often conceptualised cross-national institutional differences as sources of uncertainty, adaptation cost, and liability. By contrast, we show that, in the environmental domain, institutional diversity can generate beneficial firm-level governance responses. Specifically, when environmental performance is evaluated holistically and firms face reputational exposure across subsidiaries, greater environmental institutional diversity makes internal performance discrepancies more visible, raises the salience of underperforming units, and induces firms to strengthen internal standardisation and upgrading. In this sense, our central contribution is to reconceptualise environmental institutional diversity not only as a source of complexity, but also as a governance catalyst.

Second, we strengthen this contribution by specifying the mechanism through which EID becomes performance-enhancing, thereby also contributing to research on MNE governance and internalisation theory. Our findings are consistent with work suggesting that exposure to multiple institutional demands can stimulate organisational adaptation and internal restructuring (Greenwood et al., 2011; Pache & Santos, 2010), but we provide a more precise IB explanation of how this occurs within the MNE. We theorise EID as inducing a process of governance integration: exposure to diverse environmental regulatory environments creates multiple regulatory reference points, increases transparency regarding environmental performance differences across subsidiaries, and heightens legitimacy risks associated with uneven compliance (Kostova & Zaheer, 1999). In response, headquarters can identify underperforming units and upgrade them through strengthened monitoring systems, standardised compliance routines, and the diffusion of superior environmental practices across subsidiaries (Christmann, 2004; Kostova et al., 2008). Importantly, the mechanism we identify is not one of convergence toward the single most stringent external regulatory standard. Rather, firms raise internal minimum environmental standards in order to upgrade weaker units and reduce internal performance variance. Framed this way, the paper extends internalisation logic into the sustainability domain by showing how MNEs internalise environmental baselines, monitoring, and practice transfer across their multinational networks. This allows us to move beyond a simple institutional-effects argument and show

how external heterogeneity is translated into internal governance responses and, ultimately, firm-level environmental performance.

Our supplementary findings further sharpen this mechanism and connect the paper to the supporting conversation on corporate sustainability/ESG in MNEs. Much of the sustainability literature shows that institutions matter for environmental performance, but the underlying organisational processes are often underspecified. Our findings suggest that multinational institutional configurations shape CEP primarily through internal governance responses. Specifically, the positive effect of EID is concentrated in operational dimensions of environmental performance, which are more directly exposed to regulatory scrutiny and more amenable to standardisation across subsidiaries. By contrast, environmental innovation does not exhibit the same pattern. This distinction is theoretically meaningful because it suggests that EID operates mainly through governance integration, monitoring, and the upgrading of weaker operational performers, rather than through the stimulation of longer-term exploratory investment. Environmental innovation is likely to depend more heavily on firm capabilities and strategic orientation than on the harmonisation pressures generated by regulatory dispersion. The absence of a significant innovation effect therefore reinforces our interpretation that EID improves CEP mainly through internal governance upgrading, giving the paper a more IB-grounded sustainability contribution rather than a generic ESG claim.

Third, we contribute to research on global governance and supranational institutions by showing that supranational institutional anchoring conditions how firms respond to environmental institutional diversity. Prior research has recognised the growing importance of supranational governance in shaping corporate behaviour (Djelic & Sahlin, 2006; Hartmann et al., 2022a), but supranational exposure is often treated as a direct or cumulative institutional influence. We offer a more differentiated account. We find that initial anchoring in a supranational institutional order strengthens the positive relationship between EID and CEP, because supranational institutions provide shared environmental standards, codified compliance templates, and intensified monitoring expectations that increase the visibility and comparability of subsidiaries' environmental conduct. At the same time, broader expansion across multiple markets within the same supranational regime does not further strengthen this relationship. This distinction is theoretically important because, although member states within a supranational regime share a common regulatory architecture, they still differ in implementation practices and enforcement intensity (Börzel, 2000; Falkner & Jaspers, 2012;

Knill & Lenschow, 1998). As firms accumulate experience across these supranationally embedded contexts, environmental governance becomes increasingly codified into centralised compliance infrastructures and standardised reporting routines (Argote & Miron-Spektor, 2011; Levitt & March, 1988; Zollo & Winter, 2002). At the same time, broader embeddedness within the same supranational institutional order increases internal coordination demands by reallocating managerial attention toward harmonisation and control (Ocasio, 1997), intensifying integration pressures (Kostova et al., 2008), and heightening coordination complexity across geographically dispersed operations (Meyer et al., 2011). Taken together, our findings suggest that what matters is not supranational exposure in a simple cumulative sense, but the distinct governance role of initial anchoring versus broader embeddedness within the same supranational institutional order.

6.3 Contributions to practice

Beyond theory, the findings carry important managerial and policy implications. For MNE managers, EID can incentivise investment in firm-wide environmental governance systems that standardise practices across jurisdictions. However, because supranational institutional anchoring functions as a threshold mechanism, governance systems should be designed for scalability. Entry into supranational regimes institutionalises baseline standards and compliance routines, potentially reducing the marginal benefits of additional exposure within similar institutional contexts. Effective environmental governance, therefore, requires anticipating how regulatory demands shift across governance levels, not merely across countries. For policymakers, the results underscore the role of supranational frameworks in shaping how firms respond to environmental institutional diversity. By harmonising rules and compliance expectations, supranational institutions influence not only corporate environmental performance levels but also the organisational mechanisms through which regulatory diversity is processed.

6.4 Limitations and future research

First, our focus on U.S.-headquartered firms in environmentally intensive sectors enhances internal validity but limits generalisability. Firms from emerging markets or less environmentally sensitive industries may face different regulatory pressures and respond differently to EID. Future research should examine more diverse geographic and industrial contexts to assess the boundary conditions of the EID-CEP relationship. Second, this study

centres on institutional influences, while firm-level strategic factors may shape how firms translate EID into environmental performance. Characteristics such as global value chain integration, subsidiary interdependence, cross-border knowledge transfer, and governance centralisation may moderate firms' responses to environmental institutional diversity. Future work could integrate institutional and strategic perspectives to better understand how organisational structure and internationalisation strategies condition the performance effects of EID. Third, we do not explicitly account for the duration of firms' operations in host countries. Insights from the liability of foreignness literature suggest that adaptation to local institutions evolves over time. Longitudinal research could examine whether experience in host markets strengthens firms' ability to leverage environmental institutional diversity.

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Tables

Table 1. Definition and Measurement of Variables

Variable	Definition	Measurement	Reference	Data Source
Environmental institutional diversity	Variation in institutions governing environmental protection and sustainability across the countries in which an MNE operates.	Asset-weighted standard deviation of host-country environmental policy stringency.	(OECD, 2025)	OECD Climate actions and policies measurement framework
Corporate environmental performance	the overall environmental consequences of firms' operations, such as emissions and resource use, measurable through both objective indicators and external evaluations, including environmental ratings.	Environmental Pillar Score	(Symeou et al., 2017; Griffin et al., 2021; Amer, 2022; Ellimäki et al., 2023; Zhang et al.; 2024; Shoham et al., 2024)	LESG Refinitiv Workspace
Supranational institutional anchoring	a binary condition reflecting whether a firm is embedded within supranational governance frameworks that establish and enforce shared rules, norms, and standards across jurisdictions.	a binary indicator of EU presence, coded as 1 if the firm has at least one foreign corporate subsidiary located in an EU member state in a given year.	(Hartmann et al., 2022)	Orbis European Union
Supranational institutional breadth	the number of distinct markets within a supranational institutional regime or region in which a firm's subsidiaries operate during a given observation period.	a multiple-EU-markets indicator, which equals one if the firm operates in two or more than mean in EU member states in a given year and zero otherwise.	(Panke & Haubrich-Seco, 2016)	Orbis European Union
Firm size	the scale or magnitude of a firm	natural logarithm of total market value.	(Aguilera-Caracuel et al., 2012; Ahmadova et al., 2023; Hart & Ahuja, 1996; Hartmann & Uhlenbruck, 2015;Crane,2025; Knez & Ready, 1997; Black & Kim, 2012)	Compustat
Firm Profitability	a firm's ability to generate profit from its operations	ROA		Compustat
Firm Age	the number of years a firm has been in operation since its establishment.	Observation year minus organisation founded year		Compustat

R&D/sales Ratio	Research and development expenditures relative to total sales revenue	R&D expenditures divided by total sales	(Alam et al., 2022, 2019; Marano et al., 2017; McWilliams & Siegel, 2001).	Financial Ratios Suite by WRDS

Table 2. Descriptive Statistics

Variable		N	Mean	SD	p25	p50	p75	Min	Max	Skewness	Kurtosis
Environmental Performance	LESG Environmental	2937	41.10	28.21	15.35	42.37	64.95	0	98.55	0.0200	1.770
Environmental Performance Score Grade	LESG EPSG score	2929	5.490	3.310	2	6	8	1	12	0.0700	1.760
Emissions Performance	LESG Emissions	2937	42.27	32.97	9.410	40.24	72.75	0	99.80	0.140	1.620
Resource Use Performance	LESG RUS	2929	47.75	33.50	16.38	48.87	78.57	0	99.80	-0.0600	1.630
Environmental Institutional Diversity (Total Assets-weighted)	EID TA	2937	0.310	0.190	0.170	0.310	0.430	0	0.860	0.370	2.840
Environmental Institutional Diversity (Sales-weighted)	EID Sales	2937	0.230	0.200	0.0500	0.220	0.360	0	0.850	0.710	3.220
Environmental Institutional Diversity (Employee-weighted)	EID Employees	2937	0.350	0.270	0.120	0.320	0.520	0	1.200	0.720	3.360
Firm Size	Size	2937	8.820	1.820	7.600	8.760	10.09	3.470	12.68	-0.0200	2.570
Firm Age	Age	2937	3.330	0.870	2.940	3.370	3.850	0	4.840	-0.740	4.120
Firm Profitability	ROA	2937	0.120	0.120	0.0900	0.130	0.180	-0.460	0.380	-1.820	10.19
R&D/sales Ratio	RDS	2937	0.120	0.380	0.0100	0.0400	0.120	0	3.480	7.600	64.56
Supranational institutional anchoring	EUNUM D	2937	0.950	0.210	1	1	1	0	1	-4.260	19.18

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 3. Pairwise correlations

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1) LESG_Enviromental	1.000											
(2) LESG_EPSG_score	0.995*	1.000										
	(0.000)											
(3) LESG_Emissions	0.885*	0.882*	1.000									
	(0.000)	(0.000)										
(4) LESG_RUS	0.893*	0.887*	0.843*	1.000								
	(0.000)	(0.000)	(0.000)									
(5) ID_TA	0.150*	0.144*	0.139*	0.145*	1.000							
	(0.000)	(0.000)	(0.000)	(0.000)								
(6) ID_Sales	0.262*	0.256*	0.251*	0.273*	0.563*	1.000						
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)							
(7) ID_Employees	0.209*	0.202*	0.184*	0.214*	0.630*	0.606*	1.000					
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)						
(8) Size	0.655*	0.653*	0.642*	0.653*	0.105*	0.214*	0.188*	1.000				
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)					
(9) Age	0.188*	0.189*	0.155*	0.164*	0.065*	0.112*	0.056*	0.136*	1.000			
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)				
(10) ROA	0.279*	0.267*	0.240*	0.272*	0.117*	0.187*	0.147*	0.368*	0.137*	1.000		
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)			
(11) RDS	-0.140*	-0.124*	-0.097*	-0.132*	-0.127*	-0.163*	-0.112*	-0.056*	-0.119*	-0.585*	1.000	
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)		
(12) EUNUM_D	0.087*	0.087*	0.051*	0.081*	0.165*	0.196*	0.254*	0.114*	-0.010	0.025	-0.048*	1.000
	(0.000)	(0.000)	(0.006)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.577)	(0.183)	(0.009)	

**** p<0.01, ** p<0.05, * p<0.1*

Table 4. VIF

Variable	VIF	1/VIF
EID_Employees	1.98	0.505792
ROA	1.84	0.544076
EID_TA	1.82	0.548843
EID_Sales	1.79	0.558990
RDS	1.62	0.618270
Size	1.27	0.787959
Age	1.04	0.962435
Mean VIF	1.62	

Table 5. Regression Results (DV: CEP)

	(1) LESG_Environmental	(2) LESG_Environmental	(3) LESG_Environmental	(4) LESG_Environmental	(5) LESG_Environmental	(6) LESG_Environmental
L. EID_TA	23.387***	10.100**	-8.577	7.504	8.445*	7.462
	(3.47)	(2.38)	(-0.87)	(1.33)	(1.83)	(1.54)
L.Age		2.471**	2.455**	2.447**	2.345*	2.325*
		(2.02)	(2.01)	(1.99)	(1.92)	(1.89)
L.ROA		-6.984	-7.278	-7.105	-6.468	-6.071
		(-0.80)	(-0.84)	(-0.81)	(-0.75)	(-0.70)
L.RDS		-8.297***	-8.339***	-8.108***	-7.667***	-7.497***
		(-4.19)	(-4.22)	(-4.08)	(-3.91)	(-3.78)
L.msize		10.490***	10.509***	10.411***	10.004***	9.969***
		(21.85)	(21.82)	(21.37)	(18.29)	(17.58)
1L.EUNUM_D			-4.256			
			(-0.99)			
1L.EUNUM_D#cL.ID_TA			20.113**			
			(2.04)			
1L.EUNUM_2				1.208		
				(0.43)		
1L.EUNUM_2#cL.ID_TA				2.761		
				(0.38)		
1L.EUNUM_M					5.759	
					(1.60)	
1L.EUNUM_M#cL.ID_TA					-2.872	
					(-0.34)	
L.EUNUM_city						0.397
						(1.21)

cL. EID_TA #cL.EUNUM _cty						0.058
						(0.09)
_cons	35.949***	-59.165***	-55.438***	-59.276***	-56.294***	-56.005***
	(13.74)	(-11.34)	(-8.74)	(-11.28)	(-10.47)	(-10.23)
IndustryFE	Yes	Yes	Yes	Yes	Yes	Yes
YearFE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.123	0.531	0.532	0.531	0.535	0.535
Observations	2528.000	2528.000	2528.000	2528.000	2528.000	2528.000
N	344.000	344.000	344.000	344.000	344.000	344.000

t statistics in parentheses * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 6. 2SLS Results

	(1) First Stage	(2) Second Stage	(3) First Stage	(4) Second Stage	(5) First Stage	(6) Second Stage
L. EID_TA		3.809		1.847		4.039
		(5.173)		(6.212)		(5.179)
L.IV1	6.045***				6.816***	
	(0.603)				(0.693)	
L.IV2			5.617***		-1.206	
			(0.798)		(0.919)	
L.IV3						
L.Age	0.008	2.820**	0.009	2.840**	0.008	2.818**
	(0.006)	(1.226)	(0.008)	(1.223)	(0.006)	(1.226)
msize	0.005	10.412***	0.006	10.428***	0.006	10.410***
	(0.003)	(0.483)	(0.004)	(0.488)	(0.003)	(0.483)
ROA	-0.057	-10.654	-0.026	-10.620	-0.058	-10.658
	(0.057)	(8.913)	(0.069)	(8.943)	(0.057)	(8.910)
RDS	-0.060***	-10.989***	-0.066***	-11.130***	-0.060***	-10.972***
	(0.020)	(2.516)	(0.022)	(2.501)	(0.020)	(2.519)
Obs	2516	2516	2516	2516	2516	2516
R2		0.465		0.464		0.465
Kleibergen-Paap rk LM statistic		43.505		24.674		47.181
Kleibergen-Paap Wald rk F statistic		100.454		49.512		69.210
Cragg-Donald Wald F statistic			.		.	

Hansen J statistic	0.000	0.000	0.343
p-value of Hansen J			0.558

Standard errors in parentheses
Note: Cluster-robust standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Table 7. GMM Results

VARIABLES	(1) LESG_Enviromental
L.LESG_Enviromental	1.035***
	(0.0350)
L. EID_TA	0.244
	(0.950)
L.Age	-0.758***
	(0.210)
msize	-0.675*
	(0.386)
ROA	5.838***
	(2.145)
RDS	1.588*
	(0.841)
Constant	8.642***
	(2.219)
Observations	2,516
Number of code	342
AR(1) p	0
AR(2) p	0.718
Hansen p	0.0678
Obs	2516
Instruments	22

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 8. Robustness Test

	(1) LESG_Environmental	(2) LESG_Environmental	(3) LESG_EPSG_score	(4) LESG_Environmental	(5) LESG_Environmental	(6) LESG_Environmental
L.EID_Sales	14.881***					
	(3.49)					
L.Age	2.266*	2.478**	0.294**	2.397*		
	(1.84)	(2.02)	(2.02)	(1.95)		
L2.Age					1.948	
					(1.56)	
Age						3.063**

						(2.57)
L.msize	10.311***	10.400***	1.234***	10.770***		
	(21.62)	(21.28)	(22.17)	(21.98)		
L2.msize					10.568***	
					(21.27)	
msize						10.246***
						(21.98)
L.ROA	-7.284	-7.337	-0.953			
	(-0.84)	(-0.84)	(-0.93)			
L2.ROA					-9.063	
					(-0.96)	
ROA						-6.979
						(-0.85)
L.RDS	-7.835***	-8.318***	-1.035***			
	(-4.05)	(-4.16)	(-4.26)			
L2.RDS					-7.908***	
					(-3.54)	
RDS						-8.753***
						(-4.21)
L.ID_Employees		7.030**				
		(2.29)				
L.EID_TA			1.181**			
			(2.38)			
L2.EID_TA					9.142**	
					(2.09)	
EID_TA						9.752**
						(2.47)
L.EID_TA_w				10.451**		
				(2.26)		
L.ROA_w				-8.217		
				(-0.73)		
L.RDS_w				-35.802***		
				(-2.69)		
_cons	-57.221***	-57.607***	-6.316***	-59.547***	-55.651***	-60.583***
	(-11.30)	(-11.26)	(-10.31)	(-11.55)	(-10.18)	(-12.05)
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes
YearFE	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.535	0.530	0.524	0.530	0.517	0.530
Observations	2528.000	2528.000	2521.000	2528.000	2201.000	2937.000

N	344.000	344.000	343.000	344.000	319.000	365.000

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 9. Supplementary Test

	(1) LESG_Emissions	(2) LESG_RUS	(3) LESG_EIS
L. EID_TA	12.555**	12.766**	6.540
	(2.45)	(2.45)	(1.01)
L.Age	1.980	1.694	3.750**
	(1.49)	(1.29)	(2.17)
L.msize	12.137***	12.809***	6.308***
	(22.11)	(24.14)	(7.87)
L.ROA	-7.586	-3.405	-15.902
	(-0.79)	(-0.34)	(-1.23)
L.RDS	-5.044**	-9.328***	-12.872***
	(-2.27)	(-4.04)	(-3.48)
_cons	-71.701***	-71.273***	-34.202***
	(-12.02)	(-12.32)	(-4.37)
IndustryFE	Yes	Yes	Yes
YearFE	Yes	Yes	Yes
R-squared	0.515	0.529	0.227
Observations	2528.000	2521.000	2521.000
N	344.000	343.000	343.000

t statistics in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Figure

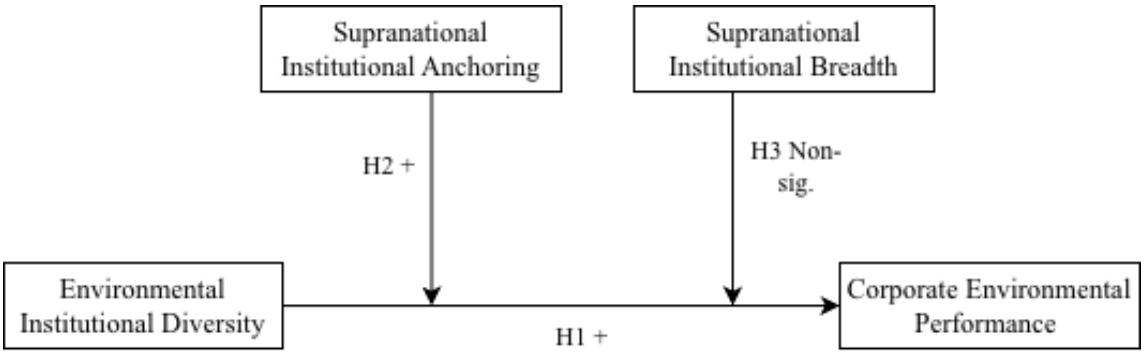

Figure 1. Conceptual Model

Mid-Year Review (2025-2026):
Does inventors' international exposure influence the creation of impactful technologies in MNEs

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Table of content

1 Abstract

Although multinational enterprises increasingly rely on globally distributed inventor teams, evidence on how inventors' international exposure affects the creation of impactful technologies remains limited. Drawing on theories of knowledge recombination, I investigate how the geographic dispersion of inventor teams and their prior patenting experience across countries influence firms' inventive performance, and how these effects are conditioned by firms' positions in technology space and collaboration networks. Using a large-scale patent-level dataset covering multinational firms and inventor teams from 1978-2019, I examine how international and experiential diversity within patenting teams relates to the subsequent impact of patents, as measured by forward citations, and how these effects depend on firms' technological and organizational contexts. I illustrate that greater international and experiential diversity within inventor teams is positively associated with invention impact. Moreover, these benefits are amplified when firms occupy more differentiated positions in technology space and are more centrally embedded in collaboration networks, suggesting that firm-level knowledge positioning and integration capacity enhance the value of team diversity. The findings advance the microfoundations of innovation by linking team composition to firm-level technological and organizational conditions, and by identifying when diversity in inventor teams is most likely to translate into impactful inventions.

2 Introduction

MNEs (Multinational Enterprises) are expected to have an innovation advantage because they span countries and access heterogeneous knowledge (Collinson and Liu, 2019), yet we still know little about the micro-level conditions under which this international knowledge base is converted into impactful inventions. From the perspectives of internalization theory and the KBV (knowledge-based view), MNEs serve as the most efficient means of developing and transferring its stock of proprietary technologies across national boundaries (Kafouros et al., 2022; Kogut and Zander, 1993). Although MNEs are expected to benefit from cross-border knowledge access, it remains unclear why some internationally exposed inventor teams generate highly impactful inventions while others do not.

This variation in the effectiveness of knowledge recombination is particularly critical because firms ultimately compete on the ability to generate impactful innovations rather than mere inventions. Companies, especially those in high-tech industries that rely on technology to generate high profits, regard innovation as an important strategy for the development of companies during internationalization. Patenting is fundamental to innovation across numerous sectors, including information technology, telecommunications, automobiles, pharmaceuticals, biotechnology, aerospace, and oil and gas (Choudhury and Haas, 2018). Thousands of

technologies (patents) are created every year, yet only a small portion of them have a significant impact on technological progress. In prior literature, patents that receive more citations are typically considered impactful. Impactful patents can enhance a company's technological capabilities or production efficiency, increase its valuation, and generate higher profits for the company when the patents are commercialized (Kafouros et al., 2025). It is essential for firms to learn about how impactful patents are invented.

A large body of research has examined the factors influencing firms' innovation from a KBV perspective by adopting institutions such as subsidiaries or R&D branches as the unit of analysis (Frost et al., 2002; Mudambi and Navarra, 2004; Singh, 2008).However, this stream of work has two major limitations, lacking micro-foundations and paying insufficient attention to the interaction between individual behaviors and firms they belong to. From a microfoundations perspective, macro-level constructs such as firm capabilities and innovation outcomes are not self-contained explanatory entities but emerge from underlying individual-level actions and interactions (Zeng et al., 2023). In the context of inventive activity, the generation of impactful innovations depends on how individual team members acquire, interpret, and recombine heterogeneous knowledge. Therefore, organizational and network-level structures influence innovation outcomes primarily as they shape individuals' opportunities and constraints in knowledge exchange and recombination.

This paper takes inventor teams within MNEs as the unit of analysis and investigates how the composition of R&D (research and development) teams drives the generation of high-impact technologies. Prior studies have consistently shown that team-based invention, compared to solo inventors, offers distinct advantages, particularly due to the recombination of diverse knowledge components (Fleming, 2007; Singh and Fleming, 2010). Effective organization and configuration of team members to produce impactful inventions have become an important strategic focus for companies. Team diversity that has been studied includes gender (Chan et al., 2023), age scope (Lai and Su, 2024), technology variety (Damioli et al., 2024; Huo et al., 2019) affiliations with formal organizational units and informal organizational communities (Choudhury and Haas, 2018), TMT (top management team) or team members' knowledge diversity (Ghazal et al., 2024; Lee and Chung, 2022; Yan et al., 2024), nationality diversity of immigrants in teams (Kang and Nabeshima, 2021, 2021; Marino and Quatraro, 2023), cultural differences, and heterogeneous knowledge (Jiao et al., 2022).

Building on one of the distinguishing features of MNEs, namely that their subsidiaries and branches are located across different countries, this paper investigates the impact of inventors' international exposure on firm innovation. Specifically, international diversity and overseas experience are used to capture teams' simultaneous and sequential exposure to heterogeneous knowledge, respectively.

International diversity refers to the variety of countries in which the inventors are currently located. Research findings on international diversity have shown different results in different contexts, making their influence on inventive performance needs more exploration. Kafouros et al. (2025) argue that international diversity enhances

innovation performance across different levels of technological complexity. However, other scholars contend that the benefits of international diversity for patents are limited. Kang and Nabeshima (2021) found that the national diversity of inventors has a positive impact on invention quality indicators. However, as nationality diversity increases, its negative effects gradually emerge, exhibiting an inverted U-shaped effect. A similar inverted U-shaped curve also occurs in green patents (Marino and Quatraro, 2023). As racial diversity increases, the likelihood of obtaining green patents declines after reaching a peak.

The complexity of MNEs' geographical distribution also brings about complexity in inventors' overseas working experience and collaboration networks. This paper argues that inventors' overseas experience enables them to be exposed to diverse technological trajectories and to develop a better understanding of different institutional and market demands, thereby contributing to the production of more impactful inventions. Building on prior research that has examined inventors' leadership experience (Choudhury and Haas, 2018), patenting experience (Singh and Fleming, 2010), and knowledge experience within the same technological domain (Taylor and Greve, 2006), this study instead focuses on inventors' experience in filing patents across foreign countries.

For the contextual factors, this paper investigates how firms' technological differentiation and positions collaboration network moderate the impact of team diversity on innovation, recognizing that individuals in teams are inevitably influenced by the organizations and environments they are embedded in (Foss and Pedersen, 2019; Larsen et al., 2023). Knowledge recombination theory posits that innovation arises from novel combinations of existing knowledge elements (Kogut & Zander, 1992). Team international exposure introduces heterogeneous knowledge, perspectives, and problem-solving approaches that expand the pool of potential ideas. However, transforming these heterogeneous inputs into concrete innovative outcomes requires firm-level capacities to absorb, integrate, and recombine knowledge.

In this study, firms' technological differentiation and firms' overseas network position are introduced to reflect internal knowledge heterogeneity and access to external heterogeneous knowledge, respectively. Technological differentiation refers to the extent of technological knowledge overlaps among a firm's existing patents. Firms with more differentiated technological positions possess broader internal knowledge structures, which facilitate cross-domain recombination and reduce the risk that novel ideas are assimilated into existing dominant trajectories. Overseas network position refers to the betweenness centrality of a firm within the international co-invention network. Firms occupying more central positions in collaboration networks benefit from greater access to external complementary knowledge and more efficient coordination mechanisms (De Prato and Nepelski, 2014), which further support the integration and exploitation of diverse knowledge inputs. As a result, the innovative benefits of team international exposure are more likely to materialize when firms exhibit stronger knowledge recombination capabilities.

3 Literature review

3.1 How does team-level diversity affect firms' inventions?

Earlier studies have examined the differences between teams and individuals in terms of their impact on innovation performance (Fleming, 2007; Singh and Fleming, 2010). The results indicate that while team collaboration enhances the likelihood of generating breakthrough inventions, it simultaneously reduces the occurrence of extreme failures (Singh and Fleming, 2010). Therefore, for firms, establishing invention teams represents a wiser choice. This naturally raises the question of what type of invention team composition can more effectively foster innovation.

Scholars generally categorize team diversity into relations-oriented diversity and task-oriented diversity (Jackson et al., n.d.; Joshi and Roh, 2009). Relations-oriented diversity refers to demographic characteristics that are visible and largely immutable, such as gender, race or ethnicity, and age. Task-oriented diversity, by contrast, captures differences among team members in knowledge, skills, and experiences that are directly related to the work tasks (Joshi and Roh, 2009). Most studies examine both types of diversity simultaneously.

Table 1 provides an overview of studies that investigate team diversity as the independent variable in relation to technology impact as the dependent variable. A subset of three studies adopts alternative dependent variables (knowledge diffusion patterns, knowledge acquisition and knowledge sharing effectiveness), which, although not directly measuring technology impact, are nonetheless regarded within the Knowledge-Based View (KBV) as influential factors shaping innovation performance and quality.

Classical definition of invention as a novel amalgamation of elements, concepts, or procedures (Fleming, 2007). It can be seen as novel variations driven by recombination of existing knowledge (Choudhury and Haas, 2018), or from the formation of novel connections among previously integrated components (Bercovitz and Feldman, 2011; Henderson and Clark, 1990). Based on this definition of invention, diversity in teams helps team members access more knowledge that can be used for restructuring (Choudhury and Haas, 2018) and generate more unexplored combinations (Singh and Fleming, 2010).Compared to lone inventors, collaborative inventors not only increase the probability of achieving breakthroughs but also reduce the likelihood of particularly poor outcomes. This is because the diversity of team members' experiences enhances the efficiency of the screening phase in the invention process, while the expanded social networks of team members enable inventors to more easily identify overlooked issues and subsequently address outliers at the tail end (Singh and Fleming, 2010). Choudhury and Haas (2018) categorized diversity based on team members' technical fields, departments, and areas of interest, finding that team diversity enhances patent scope, manifested by patents securing more claims, which in turn significantly reduces the risk of patent infringement.

However, teamwork is not beneficial for patent applications if the collaboration remains for a long time. Inoue (2015) found that prolonged teamwork can lead to a decline in the team's inventive capabilities. Fortunately, developing technological

diversity and diversity among inventors within the team can prevent such decline. Common forms of diversity include multidisciplinary collaboration, but research indicates that the greater the differences between collaborators' professional fields, the lower the overall quality of their outcomes. Therefore, when forming diverse teams, companies should prioritize depth over breadth, as individuals with deep expertise are more likely to identify potential cross-disciplinary synergies (Fleming, 2007).

Specifically, regarding international diversity, the mainstream view holds that it enhances inventive performance. Ferrucci and Lissoni (2019) follow the clarification by Harrison and Klein (2007), dividing diversity into disparity, separation, and variety to examine the impact of diversity on invention performance. During the early stages of invention, disagreements among team members are seen as a favourable condition for the emergence of innovation. The positive effects of the variety element outweigh the negative effects of the separation element, so national diversity within an inventor team has a positive impact on team performance. Additionally, technology typically requires heterogeneity in ideas, concepts, and inputs (Kafouros et al., 2025). Some studies have pointed out that collaborators with high racial similarity exhibit weaker inventive performance, including in papers (Freeman and Huang, 2015) and patents (Almeida et al., 2015). Therefore, teams with international diversity have a higher likelihood of creating influential technologies (Kafouros et al., 2025). Furthermore, diversity can enhance a team's ability to discover various potential combinations by reducing cognitive similarity within the invention team. Thus, even when faced with technological complexity, diverse teams can effectively delay the negative impact of technological complexity on team innovation levels by leveraging a broad knowledge base and diverse perspectives (Kafouros et al., 2025).

However, some scholars argue that the benefits of diversity diminish as the degree of diversity increases. Kang and Nabeshima (2021) found in a study of Japanese patents that the diversity of inventors' nationalities has a positive impact on invention quality metrics. However, as nationality diversity increases, racial diversity can hinder information simplification and integration due to communication gaps, leading to negative effects gradually emerging. Marino and Quatraro (2023) suggest that diversity in R&D teams also has a similar effect on the intention to obtain green patents. The higher the racial diversity, the greater the likelihood of obtaining green patents; however, as heterogeneity increases, the ability to integrate and implement different ideas diminishes, weakening the aforementioned relationship. Therefore, despite the abundance of research on the impact of diversity on invention performance, further exploration is warranted.

3.2 Theory

The knowledge-based view (KBV) of the firm will serve as the theoretical foundation of my study. This perspective conceptualizes the firm as a repository and integrator of knowledge, which exists because it enables more efficient knowledge transfer and replication than the market (Grant, 1996; Kogut and Zander, 1992). Firms create competitive advantage by accumulating and recombining capabilities, and the heterogeneity of these capabilities is rooted in distinct paths of knowledge integration. Knowledge is embedded not only in individuals but also in organizational routines,

structures, language, and coordination mechanisms—thus, it is inherently social and path-dependent. Successful firms that produce differentiated products possess market-relevant knowledge, which can be transferred to other markets at minimal cost (Kogut and Zander, 1992).

Building upon this foundation, Kogut and Zander (1993) further integrated evolutionary theory and capabilities-based theory to explain the emergence and advantages of multinational enterprises (MNEs). They argued that the advantages of MNEs stem from three core capacities: (1) R&D capabilities that underpin technological leadership; (2) the development of cohesive, complementary team skills that generate synergistic returns; and (3) the establishment of internal communication systems that facilitate the dissemination of firm-specific advantages while safeguarding proprietary knowledge.

To further support the knowledge-based interpretation of firm innovation—particularly in diverse and cross-border team contexts—this study also draws on knowledge management theory, with a specific focus on knowledge combination. Knowledge management theory is a theoretical framework that studies how to effectively acquire, analyze, store, and disseminate knowledge (Alavi and Leidner, 2001). It involves how organizations use knowledge to improve efficiency, innovation and competitiveness. The main components of a complete knowledge management theory include the types of knowledge, knowledge acquisition and creation, knowledge storage, knowledge sharing and dissemination, knowledge application and technical support. Knowledge recombination concept belonging to knowledge management theory refers to the process of integrating and restructuring existing knowledge elements in novel ways to generate innovative outcomes (Singh and Fleming, 2010). It lies at the core of knowledge-based theories of the firm and plays a vital role in explaining how firms leverage their knowledge assets for innovation.

According to Kotabe (2007), innovation performance is a curvilinear function of the international knowledge content utilised by enterprises for innovation. At low to moderate levels of international knowledge content, enterprises' techniques for transferring international knowledge can enhance their innovation performance. However, at high levels of international knowledge content, the marginal returns from information transferred from abroad diminish (Kotabe et al., 2007). Salomon (2006) suggests exporters possess access to diverse knowledge inputs that are unavailable in the domestic market, based on the expost innovation return. This knowledge is returned to the focal firm and enhances innovation (Salomon, 2006).

Table 1 Research on the impact of team diversity on inventions

Article	Sample	IV	MOV	MEV	DV
Indirect impact on inventions					
(Singh, 2005)	Patents from USPTO	Collaborative ties, social distance, geographic location, firm affiliation			Knowledge diffusion patterns
(Tortoriello et al., 2012)	a European MNC in the chemicals industry	Tie strength, network cohesion, network range			Knowledge acquisition
(Ambos et al., 2016)	Global product development teams from 42 MNCs	Team imbalance, team isolation		Social integration mechanism, communication & trust mechanism	Knowledge sharing effectiveness
Direct impact on inventions					
(Mack et al., 2025)	S&P 1500 firms and their patenting activities	Board diversity (Gender, ethnicity, industry experience)	Number of inside executive directors	TMT Diversity, inventor diversity	Invention output: number of patents and number of citations
(Damioli et al., 2024)	Multinational firms with subsidiaries across 185 countries	International inventor teams	Technological innovation capability		Technological variety
(Marino and Quatraro, 2023)	Covering US-based MNEs	Ethnic diversity in the R&D team			Generation of green technologies
(Jiao et al., 2022)	Patents in the computer workstation related domains from USPTO	Productivity gap, prior ties, team knowledge similarity			Patent impact

(Seo et al., 2020)	Top 25 multinational pharmaceutical companies	Geographic diversity, experience Heterogeneity, repeated Collaboration			Innovation Performance: impact and novelty
(Huo et al., 2019)	U.S. utility patents	Technological variety, technological dissimilarity			Invention impact： forward citations
(Ferrucci and Lissoni, 2019)	Patents filed at EPO and USPTO (Europe and US)	Nationality diversity of inventor team, presence of migrant inventors	Country/region		Patent quality: forward citation
(Choudhury and Haas, 2018)	121 teams that filed patents in a Fortune 50 companie's India R&D center	Team diversity: formal unites& informal communication	Leader experience	Patent application scope	Patent approval speed
(Vakili and Kaplan, 2021)	Patent data from USPTO on all utility patents	Team size, cognitive focus, experiential diversity, team familiarity			Innovation impact: forward citations
(Singh and Fleming, 2010)	US patents from USPTO	Team or not, assigned by an organization or not		Experience diversity, network size	Innovation impact: future citations

(Fleming, 2007)	10% sample of all patented U.S. inventors	Type of collaboration brokered/cohesive), multidisciplinarity		Number of inventions, average score of inventions, maximum scores, variance of inventive outcomes
(Taylor and Greve, 2006)		Team knowledge diversity, team experience, individual knowledge diversity	Team size, past collaboration experience	Mean product performance, variance in product performance, extreme innovation success/failure
(Lee and Chung, 2022)	US firms	proportion of women in TMT		Number of firm's innovations, impact of the firm's innovations, extent of local search
(Kaltenberg et al., 2023)	Firms in Switzerland, Germany, Austria	Inventor age		Patent rate, patent impact, number of claims, disruptiveness, generality, originality
(Chan et al., 2023)	Patents granted to U.S. public corporations listed on a major U.S. stock exchange	Expertise similarity, network cohesion, gender Diversity		Patent value: market reactions to patent grant announcements)
(Kafouros et al., 2025)	2,343,712 EPO and PCT patents	Technological complexity, international diversity, inventor team expertise		Impact of technology
		Ultimate impact of inventions		
(Kaczmarek and Ruigrok, 2013)	Stock exchange-listed companies from the Netherlands, Switzerland, and the UK	TMT nationality diversity	Firm internationalization degree, country	Firm performance

4 Conceptual framework

4.1 International diversity and overseas experience

The key advantage of multinational companies lies in their ability to fully leverage the resource advantages of different countries and regions around the world for resource allocation. This advantage manifests itself in the MNE's capacity to recruit talent worldwide and to establish global innovation networks. Previous literature has studied the significance of cross-border cooperation between MNE organisations for knowledge transfer (Park, 2011). This paper aims to further explore this issue from the micro perspective of team inventors.

The first objective of this research is to study the impact of team **international diversity** on impactful inventions. International diversity is typically measured by the variety of countries represented in the team (Kafouros et al., 2025). The more countries where inventors currently reside, the higher the international diversity of the team. This paper believes the international diversity will have positive impact on inventions based on reasons following. First, based on KBV, when team members are located in different countries, MNEs play a role in integrating cross-national diverse knowledge (Grant, 1996; Kogut and Zander, 1993). Second, the combination of knowledge from diverse sources enhances the novelty and complexity of inventions, while international diversity is a key source of such heterogeneous knowledge (Fleming, 2001). Inventors based in different countries are exposed to diverse cultural, institutional, and educational backgrounds, and these differences can lead to more diverse knowledge, which will enable MNEs to offer more combinable knowledge components. In contrast, imbalanced team composition may lead to resources and decision-making power being concentrated in the majority group, thereby hindering knowledge sharing and integration within multinational teams (Ambos et al., 2016). Based on the above discussion, this paper proposes the first hypothesis:

Hypothesis 1 International diversity within a team has a positive effect on the creation of impactful technologies.

This study will examine the impact of **overseas experience** among team inventors on invention quality. Overseas experience refers to whether an inventor has previously applied for patents from countries other than their current country of residence. Prior research has identified inventor mobility as a key channel for knowledge spillovers (Almeida and Kogut, 1999; Rosenkopf and Almeida, 2003). When inventors have lived and worked in different countries and filed patents during those periods, they often bring with them both explicit and tacit knowledge related to technological standards, market demands, and institutional norms from various countries and organizations. Such cross-border knowledge experiences significantly enrich the team's knowledge base and enhance the firm's ability to efficiently reconfigure and recombine knowledge, ultimately boosting the novelty and value of patent output. In addition, international experience often leads to broader collaboration networks, which facilitate the diffusion of information (Singh, 2005)

and create access to new knowledge, resources, and partnership opportunities (Hoisl, 2007). These benefits collectively contribute to accelerating the innovation process. Based on this, the following hypothesis is proposed:

Hypothesis 2 Overseas experience of team members has a positive effect on the creation of impactful technologies.

4.2 The moderating effect of overseas network position and technological differentiation

Since the impact of diversity may vary under different actual conditions (Kang and Nabeshima, 2021), this study will examine the role of firms on the impact of team diversity. Knowledge recombination theory suggests that innovation emerges from novel combinations of existing knowledge components. The creation of impactful patents therefore depends on both access to heterogeneous knowledge and the capability to integrate such knowledge effectively. The paper believes that these two critical capabilities are reflected in firms' positions in collaboration networks and in technology space respectively. Whereas network position captures firms' access to external knowledge channels, technology-space position reflects the extent of firms' technological differentiation.

Overseas network position refers to the betweenness centrality of a firm within the international co-invention network. Firms located at the core of global collaboration networks typically exhibit higher levels of centrality or brokerage. Such advantageous network positions enable them to access diverse knowledge from a variety of global sources more efficiently, facilitating rapid information exchange and the integration of knowledge across geographical and technological boundaries (Fleming et al., 2007b, 2007a). Being central in international innovation networks not only increases a team's access to various types of knowledge and technological resources (De Prato and Nepelski, 2014), but also enhances its capacity to absorb and leverage emerging global innovation trends. These capabilities significantly improve the likelihood of producing high-impact patents. Based on this, the following hypothesis is proposed:

Hypothesis 3 Overseas network position of a team has an effect on the creation of impactful technologies.

Technological differentiation refers to the extent of technological knowledge overlaps among a firm's existing patents. Greater technological differentiation reflects more heterogeneous combinations of knowledge (Huo et al., 2019). This paper believes that, in firms with high technological differentiation, diverse teams are more likely to create impactful innovations. Team diversity—stemming from inventors' varied nationalities, international experience, and global collaboration networks—brings a wide range of perspectives and ideas (Harrison and Klein, 2007; Singh and Fleming, 2010). Whether a firm have the ability to convert the diversity into valuable innovation depends on whether it can pool together different expertise (Huo et al., 2019).

As platforms for knowledge absorption and transfer (Jane Zhao and Anand, 2009; Park, 2011), MNEs that incorporate a wider range of technological knowledge combinations in their patents accumulate richer experience in managing diverse

knowledge bases. Such experience alleviates the communication burden among inventors from different backgrounds. For instance, when two inventors with distinct expertise collaborate, they must integrate two different knowledge elements into the invention. If the firm has previously combined these fields in its patents, the collaboration can draw on existing routines, infrastructure, and prior experience, thereby facilitating a smoother process. By contrast, if the firm lacks prior experience with this technological combination, the invention team is more likely to face difficulties in integrating the two knowledge domains, which may hinder patent outcomes. Therefore, this study proposes that

Hypothesis 4: Technological differentiation will positively moderate the relationship between team diversity and the creation of impactful technologies.

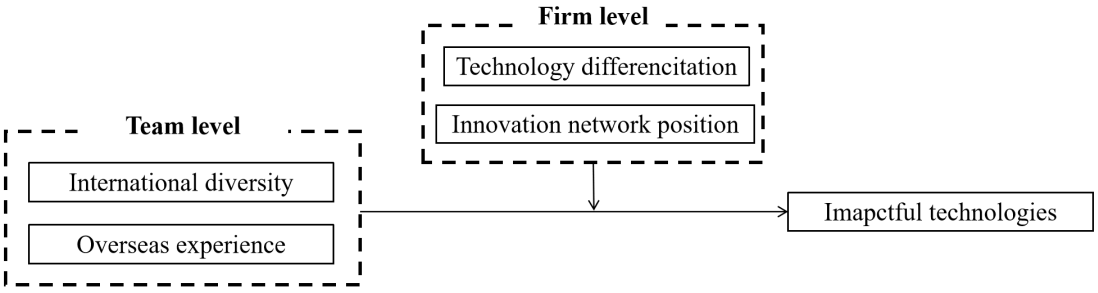

Figure 1 Research design

5 Methodology

5.1 Sample selection and data source

Figure 2 presents the databases used in this study, the tables used within each database, and their data providers. To test the hypotheses, I initially collected data on the patents (inventions) developed by firms using patent data from the OECD (Organization for Economic Co-operation and Development) REGPAT database. This includes patent applications filed in the European Patent Office (EPO) and Patent Cooperation Treaty (PCT) since 1978. OECD_RAGPAT includes 10 tables. Basic patent information and applicant-related data are obtained from EPO_APP_REG and PCT_APP_REG, while inventor information is sourced from EPO_INV_REG and PCT_INV_REG. I matched EPO and PCT priority numbers and excluded duplicate patent applications by EPO and PCT respondence.

I also obtain data on forward citations from OECD_Quality and OECD_Citations. These databases draw data from the Worldwide Statistical Patent Database (PATSTAT), providing a comprehensive coverage of citations globally. I considered a 5-year forward citation window for our analysis, and thus, the citation data I collected includes citing patents until the end of 2019.

To identify patents filed by firms, Orbis IP (Orbis Intellectual Property) database by BvD (Bureau van Dijk) is employed. It combines company and patent information for intellectual property management and strategy, such as publication information, ownership, industry and patent classifications, oppositions, and patent value. By

matching patent numbers, I linked the OECD patent data with Orbis-IP data, retained only the observations that appear in both the OECD and Orbis IP datasets and excluded patents that involve only a single inventor. Consequently, my sample comprised 2,585,000 EPO and PCT patents that were matched with 186,150 firms recorded in Orbis-IP, spanning from 1978 to 2019. The sample of firms covers 139 countries, including developed and emerging economies. Figures 3 and 4 illustrate the global distribution of sample patents and sample firms. Table 2 shows the year distribution of the sample patents.

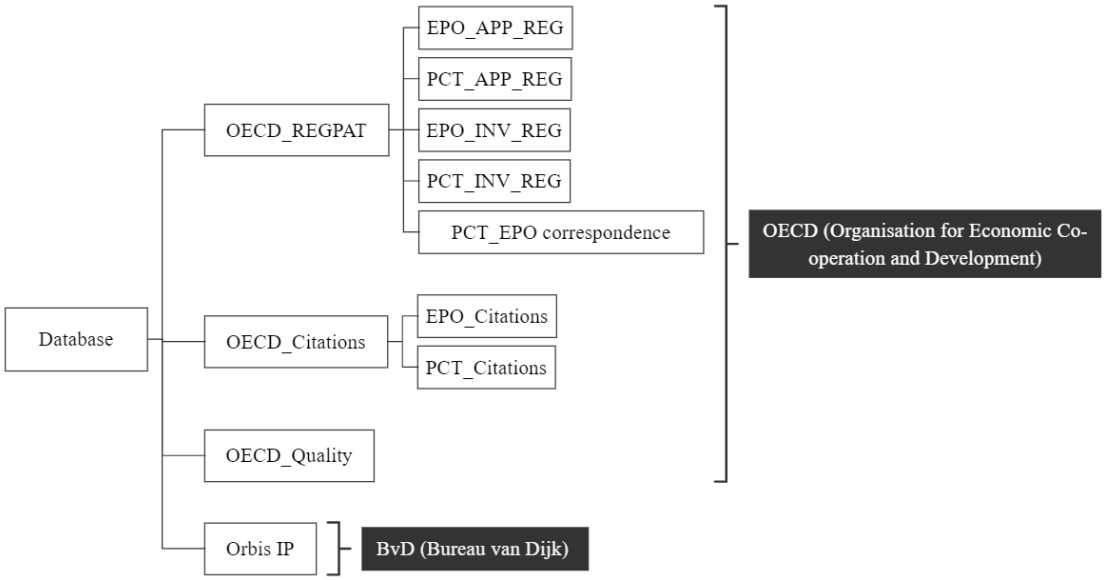

Figure 2 Databases, tables used within each database, and data providers

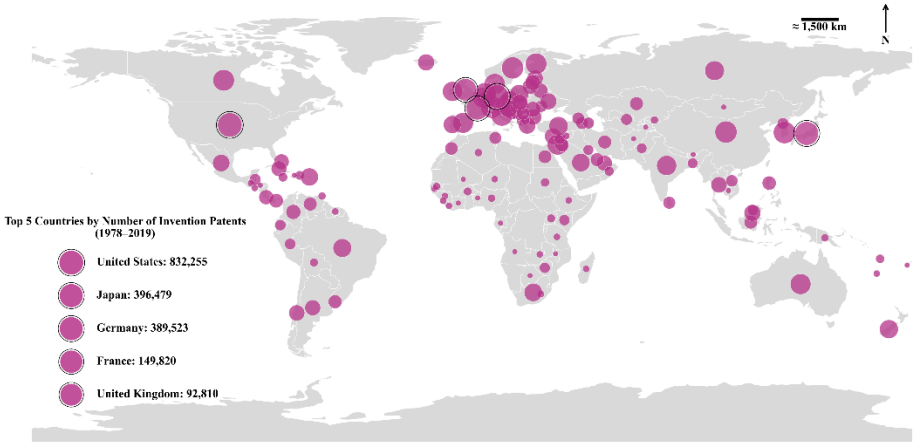

Figure 3 Global distribution of patents in major countries (1978-2019)

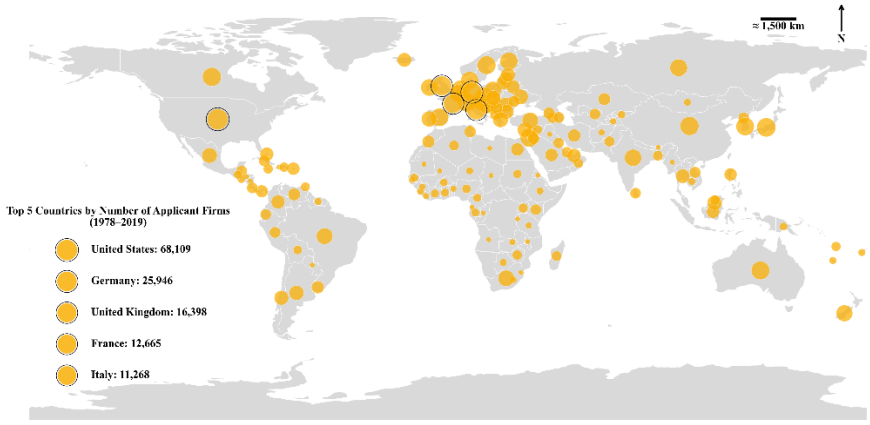

Figure 4 Global distribution of patent applicants in major countries (1978-2019)

Table 2 Patents distribution by year

Year	Number of patents	Percentage
1978	231	0.009%
1979	1080	0.042%
1980	1558	0.060%
1981	1717	0.066%
1982	1947	0.075%
1983	2080	0.080%
1984	2440	0.094%
1985	3266	0.126%
1986	3623	0.140%
1987	4635	0.179%
1988	6327	0.245%
1989	7738	0.299%
1990	10589	0.410%
1991	12681	0.491%
1992	14581	0.564%
1993	17287	0.669%
1994	20999	0.812%
1995	25712	0.995%
1996	31891	1.234%
1997	40048	1.549%
1998	62013	2.399%
1999	94425	3.653%
2000	132791	5.137%
2001	148781	5.756%
2002	149247	5.774%
2003	113577	4.394%
2004	87487	3.384%
2005	92864	3.592%
2006	96585	3.736%
2007	96275	3.724%
2008	95191	3.682%
2009	92439	3.576%
2010	95782	3.705%
2011	100229	3.877%
2012	103522	4.005%

2013	107075	4.142%
2014	111354	4.308%
2015	111385	4.309%
2016	115113	4.453%
2017	118896	4.599%
2018	122389	4.735%
2019	127147	4.919%
Patents with Missing dates	3	0.000%
Total	2585000	100%

5.2 Variables

5.2.1 Dependent variable

Impactful technologies. The study's dependent variable necessitates quantifying how impactful the creation of each technology (patent) is. Following established practice in prior research, this paper will measure such impact using the number of forward citations that each patent receives within a 5-year window (Fleming, 2007; Kafouros et al., 2025; Singh and Fleming, 2010). Given that some inventions were created more recently than others, the 5-year window normalizes the measure to avoid a time-related bias. The quantity of forward citations indicates the influence of a technology and reveals the extent of future references to the patent from other inventors, along with its effect on the advancement of subsequent innovations (Jaffe and de Rassenfosse, 2017).

5.2.2 Independent variable

International diversity refers to the variety of countries represented in a team inventing a patent. To measure each team's international diversity of inventors, the variety of countries represented in the team needed to be captured (Kafouros et al., 2025). First, I will identify the number of countries where the inventors listed on the patent were located. I will do so for each team separately. Then I will measure each team's international diversity by estimating the total number of different countries the inventors of each team are located. If a team has five inventors residing in three distinct nations, the measure will equal three. Thus, a larger rating denotes higher international variety within a team. This measure differs from measures that capture inventor nationality (Ferrucci and Lissoni, 2019).

Overseas experience refers the proportion of inventors listed on a patent who have previously applied for patents in countries different from their current country of residence. If an inventor listed on a patent has previously applied for patents from countries other than their current country of residence, the inventor is considered to have overseas experience. Drawing on previous research on the definition and measurement of mobility (Hoisl, 2007), a dummy variable was created, taking the value 1 if the inventor had any overseas experience, and 0 otherwise. I aggregate this measure to the team level by computing the average value across all inventors listed on a patent, which reflects the share of team members with overseas experience. For a given team, a higher value of this variable indicates that a larger share of inventors

have previously invented patents for firms located in different countries.

The main difficulty in constructing this variable lies in the fact that, unlike EPO_INV_REG, PCT_INV_REG does not assign a unique person identifier to each inventor, which may lead to name disambiguation problem. Therefore, I conduct name disambiguation specifically for inventors appearing in PCT patents. As this study focuses on inventors' overseas experience, I adopt the algorithm developed by Breschi et al. (2023) for name disambiguation. This algorithm aims to link records at the patent level using a set of strong-evidence rules and is well suited for identifying cross-border mobility and tracking inventors across locations. The detailed disambiguation procedure is as follow:

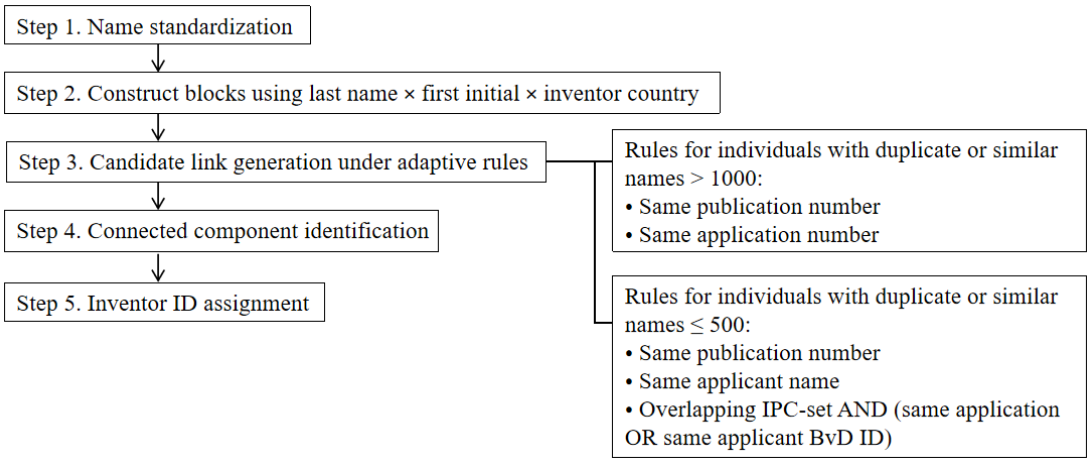

Figure 5 Disambiguation procedure according to Breschi et al. (2023)

5.2.3 Moderating variable

Technology differentiation refers to the similarity of a firm's technology space relative to its closest technological peer firms. Higher values indicate that a firm's technology portfolio is more differentiated from its closest technological peers, whereas lower values indicate greater technological similarity. In calculating $\text{tech differentiation}_{it}$, I only include the 10% most similar firms in technology space to firm i in year t, since prior research suggests that technological competition mainly occurs among the most technologically similar firms (Arts et al., 2023). This paper follow the measurement used in previous literature (Arts et al., 2023; Huo et al., 2019),

$$tech\ differentiation_{it} = 1 - \frac{1}{n-1} \sum_{j=1, j\neq 1}^{n} tech\ similarity_{itj}$$

with n equal to firms active in year t. The average the sum of all cosines is employed to generate the proxy of technology similarity for a firm (Huo et al., 2019). The cosine index for each dyad of firms is defined as follow:

$$tech\ similarity_{itj} = \frac{k_i \cdot k_j}{|k_i||k_j|}$$

where k_i and k_j are prior knowledge vectors for firm i and firm j, respectively.

Each dimension in the prior knowledge vector represents the count of a firm's patents assigned to a specific 4-digit IPC class in year t, based on Orbis IP. Note that · refers to dot product and || is the magnitude of the vector.

Overseas network position refers to the firms' betweenness centrality in the global innovation network. The betweenness centrality index reflects the position of a node as a core or a hub in the network of international technological collaboration(De Prato and Nepelski, 2014). In this study, the node is firm. For each year, I construct a firm-level collaboration network based on co-patenting relationships, where nodes represent firms and an undirected edge is formed between two firms if they jointly apply for at least one patent in that year. I then compute firms' normalized betweenness centrality in each annual network. Betweenness centrality of firm i in year t is defined as

$$betweenness\ centrality_t(i) = \frac{2}{(n_t - 1)(n_t - 2)} \times \frac{\sigma_{sj}(i)}{\sigma_{sj}}$$

where σ_{sj} denotes the number of shortest paths between firms s and j, and $\sigma_{sj}(i)$ is the number of those paths that pass through firm i. The normalization term ensures comparability across networks of different sizes.

Table 3 Variables, descriptions, measurements and related articles

Variable	Description	Measurement	Article	Database
Dependent Variables				
Impactful technologies	How impactful the creation of each technology (patent) is.	For every sample patent, the number of forward citations that each invention (patent) receives within a 5-year window.	(Kafouros et al., 2025)	OECD_ Citations
Independent Variables				
International diversity	The variety of countries represented in the team.	First, I will identify the number of countries where the inventors listed on the patent were located. I will do so for each team separately. Then I will measure each team's international diversity by estimating the total number of different countries the inventors of each team are located.	(Kafouros et al., 2025)	OECD_ Regpat
Overseas experience	The proportion of inventors listed on a patent who have previously applied for patents in countries different from their current country of residence.	First, for each inventor, a dummy variable was created, taking the value 1 if the inventor had any overseas experience, and 0 otherwise. Then the average value across all inventors listed on a patent will be calculated, which reflects the share of team members with overseas experience.	(Jiao et al., 2022; Seo et al., 2020)	OECD_ Regpat
Moderating Variables				

Technology differentiation	The similarity of a firm's technology space relative to its closest technological peers.	First, for each company i in year t, construct a technological vector using the firm's patent portfolio across IPC subclasses, where each element represents the number of patents in a given IPC category. I then compute cosine similarity between firm i and a set of technologically proximate peer firms in the same year. Peer firms are selected based on the highest overlap in IPC activity.	(Huo et al., 2019; Jiao et al., 2022, Arts et al., 2023)	Orbis IP
Overseas network position	The firm's centrality in the global innovation network.	For each year, I construct a firm-level collaboration network based on co-patenting relationships, where nodes represent firms and an undirected edge is formed between two firms if they jointly apply for at least one patent in that year. I then compute firms' normalized betweenness centrality in each annual network.	(De Prato and Nepelski, 2014)	OECD_ Regpat
Control Variables				
		Patent level		
Technology mean control	It refers to the weighted average of the mean forward citation counts of all technology classes (e.g., IPC4) associated with a patent, where the weights are based on the share of sub-classes (full IPC codes) within each class assigned to that patent. It implies the typical number of citations that patents in the same technological field tend to receive.	First, for each patent, I extract all IPC4 technology classes to which the patent is assigned. Second, I calculate the average number of forward citations received within a five-year window for each IPC4 technology class. Third, given that each patent belongs to multiple technology classes, I will assign patent specific technology control by calculating the weighted average of the technology classes assigned to the patent. The weights are calculated based on the share of sub-classes (full IPC code) within each class (IPC4 code), i.e., classes with more sub-classes assigned to the patent receive higher weights.	(Fleming and Sorenson, 2001; Kafouros et al., 2025)	Orbis_IP

Backward citations	The extent that a patent draws on prior technological developments.	The references made by a patent to earlier patents.	(Fleming and Sorenson, 2001; Kafouros et al., 2025)	OECD_ Quality
Science citations (non-patent literature references)	The strength of the linkage between a patent and the scientific knowledge.	The number of non-patent literature references made in the patent.	(Kafouros et al., 2025; Singh and Fleming, 2010)	OECD_ Citations
Number of claims/ Patent scope	It indicates the scope of novelty and boundaries of property rights represented by the patent.	The number of claims for a patent.	(Ferrucci and Lissoni, 2019; Kafouros et al., 2025; Seo et al., 2020; Singh and Fleming, 2010)	OECD_ Quality
Number of assignee firms	How many firms co-develop the patent.	The number of assignee firms of a patent.	(Kafouros et al., 2025)	Orbis_IP
Firm international experience	The extent of propensity to use international teams compared to firms with limited international experience.	The number of different countries involved in a firm's patents over the past five years.	(Kafouros et al., 2025)	Orbis_IP
Firm patent stock (log)	The stock of the firms' patents up to and including year t-1	The stock of the firms' patents up to and including year t-1	(Ferrucci and Lissoni, 2019; Kafouros et al., 2025)	Orbis_IP
Team-level				
Size of the team √	The number of inventors in the team.		(Ferrucci and Lissoni, 2019; Kafouros et al., 2025; Seo et al., 2020)	Orbis_IP
Average experience	The average number of past patents that members of this team have been involved with.	I will construct an inventor-level variable by extracting all inventor names from the dataset and counting the number of patents each inventor has been involved in. This variable was then aggregated to the team level	(Singh and Fleming, 2010)	Orbis_IP

		to calculate the average prior patenting experience of each inventor team.		
Firm-level				
Firm age	Date of incorporation.		(Seo et al., 2020)	Orbis
Firm size	Total assets of a firm.		(Lahiri, 2010; Lee and Chung, 2022; Seo et al., 2020)	Orbis
Internationalizatio n degree	the number of countries in which a company has subsidiaries			
Sales growth	The sales growth of a firm.			Orbis
Employees	Number of employees.			Orbis
R&D intensity	R&D intensity of a firm to reflect the relative intensity of innovation investment.	R&D expenses / operating revenue (%)	(Lahiri, 2010; Lee and Chung, 2022)	Orbis
Intangible assets	Intagible assets of a firm, to reflect the accumulation of knowledge capital			Orbis
Fixed assets	Fixed asstes of a firm.			Orbis
Profitability	Profitability of a firm.	Profit/loss for period (net income)	(Chan et al., 2023; Lee and Chung, 2022)	Orbis
ROE	ROE using net income (%)	Return on equity= net income/ shareholders' equity		Orbis
ROA	ROA using net income (%)	Return on assets= net income/ total assest		Orbis
Contextual variables				
Industry	The industry to which the company belongs.	Classifeid by BvD sectors.		Orbis
List	Listed/delisted/unlis ted status of a firm.			Orbis
Country_dummy	Company's country of location.	Country		Orbis

5.2.4 Estimating method

I will employ Poisson pseudo-maximum likelihood (PPML) estimation to model

patent forward citation counts:

$$E(y_{pit}|X_{pit}, \alpha_{pit}, \gamma_{pit}) = exp(X_{pit}\beta + \alpha_i + \gamma_t),$$

Where y_{pit} denotes the forward citation count of patent p filed by firm I in year t, X_{pit} includes teams' international exposure measures and other controls, and α_i and γ_t are firm and year fixed effect, respectively.

This choice is motivated by several methodological considerations. First, the dependent variable is a non-negative count variable with a highly skewed distribution and a substantial proportion of zero values, making linear regression on log-transformed outcomes inappropriate and potentially biased (Cohn et al., 2022; Kafouros et al., 2025). Second, PPML provides consistent estimates as long as the conditional mean is correctly specified, even in the presence of heteroskedasticity and over-dispersion, and therefore does not require restrictive distributional assumptions about the error term. Third, unlike negative binomial models, Poisson models with fixed effects admit a conditional likelihood that eliminates firm-specific fixed effects, thereby avoiding the incidental parameter problem when the panel has a large cross-sectional dimension and a relatively short time dimension. Finally, PPML can be efficiently implemented with high-dimensional fixed effects, allowing us to flexibly control for unobserved heterogeneity at the firm and year levels (Wooldridge, 2010). For these reasons, PPML with multi-way fixed effects is particularly well suited for modeling patent citation outcomes in our setting.

6 Results

6.1 Descriptive statistics

Table 4 presents descriptive statistics. Table 5 reports both Searman correlations. Spearman rank correlations are less sensitive to non-normality and outliers and capture monotonic relationships. As 5-year forward citations of patents are highly skewed and characterized by a small number of extremely highly cited patents, conducting Spearman correlation analysis is necessary. The consistency across the two measures suggests that the observed associations are not driven by distributional assumptions or extreme observations.

The pairwise correlations among explanatory variables are generally low, suggesting that multicollinearity is unlikely to bias the regression estimates (Porter and Gujarati, 2008; Wooldridge, 2009).

Table 4 Descriptive statistics

Variable	Obs	Mean	Std. dev.	Min	Max
Impactful technologies	19,669,140	2.890584	11.80864	0	1366
Team	23,934,068	4.422548	3.355676	2	260
International diversity	23,933,955	1.137782	0.4147712	1	14
Betweenness centrality	18,326,134	0.0028929	0.0060801	0	0.1081417
Overseas experience (dummy)	19,694,239	0.0681529	0.2520081	0	1
Overseas experience (share)	19,694,239	0.0235188	0.1043284	0	1

Technology differentiation	23,934,055	0.5013741	0.2113987	0	0.9459051
Non-patent citations	23,934,069	1.523993	12.14272	0	857
Assign firm	23,934,048	1.222121	0.5074236	1	18
Patent stock	23,932,396	861875.9	663502.8	1	2,078,691
Technology control	23,749,138	0.2572404	0.246162	0	45
Backward citations	19,667,310	7.844402	14.7919	0	1569
Patent scope	19,667,310	2.436496	1.618726	0	30

6.2 Baseline regression

As firm-level variables are still being collected, regression results are not presented at this stage.

Table 5 Spearman Correlations among Key Variables

	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1	**Impactful technologies**	1.000												
2	**Team**	0.071	1.000											
3	**International diversity**	0.006	0.172	1.000										
4	**Betweenness centrality**	-0.022	0.021	-0.028	1.000									
5	**Overseas experience (dummy)**	0.001	0.098	0.190	-0.013	1.000								
6	**Overseas experience (share)**	0.001	0.091	0.187	-0.013	0.999	1.000							
7	**Technology differentiation**	-0.048	-0.097	-0.080	0.206	-0.066	-0.065	1.000						
8	**Non-patent citations**	0.116	0.040	0.041	0.008	0.006	0.005	-0.228	1.000					
9	**Assign firm**	0.042	0.077	0.091	-0.245	0.104	0.104	-0.167	0.025	1.000				
10	**Patent stock**	-0.145	-0.015	-0.065	0.170	-0.045	-0.044	0.223	-0.034	-0.740	1.000			
11	**Technology control**	0.111	-0.033	-0.013	-0.023	0.002	0.003	0.085	-0.001	0.017	-0.077	1.000		
12	**Backward citations**	0.095	0.060	-0.026	-0.088	0.000	0.000	0.066	-0.026	0.026	0.108	0.032	1.000	
13	**Patent scope**	0.122	-0.005	0.005	-0.043	-0.010	-0.011	-0.134	0.107	0.042	-0.161	-0.210	0.060	1.000

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Enacting Entrepreneurial Agency in Contested Fields: Community Energy Organisations, Strategic Action Fields, and Divergent Trajectories

Abstract

Community energy organisations occupy a distinctive and increasingly contested position in UK energy transitions. Operating as hybrid organisations that combine civic purpose, democratic governance, and market-facing activity, they face a common institutional environment yet follow markedly different trajectories over time. Some adapt, diversify, and sustain their operations; others narrow in scope, stagnate, or fail. Existing scholarship explains the structural and institutional conditions that shape community energy relatively well, through policy analysis, niche theory, and field-level governance accounts. However, it offers a less systematic account of how organisations and the entrepreneurial actors within them interpret, navigate, and act within those conditions. This paper argues that entrepreneurial agency, as an analytical construct, has important conceptual foundations in the literature but remains fragmented, under-integrated, and inadequately theorised within community energy scholarship specifically. Agency appears across the community energy literature through proxy discussions of leadership, collective capacity, participation, and institutional entrepreneurship, but without a coherent, field-sensitive analytical framework capable of explaining within-context divergence. This paper develops such a framework by bringing foundational entrepreneurial agency scholarship into dialogue with Strategic Action Field (SAF) theory and institutional work. It argues that entrepreneurial agency in community energy is best understood as embedded, relational, and enacted within contested fields through purposive institutional work. The paper contributes to community energy scholarship, institutional theory, and entrepreneurship research, and establishes the conceptual foundation for a broader qualitative PhD investigation of divergent trajectories in UK community energy.

Keywords: community energy; entrepreneurial agency; Strategic Action Field theory; institutional work; divergent trajectories; UK energy transitions

1. Introduction

Community energy organisations have become a significant, if persistently uneven, feature of the UK energy landscape. Defined broadly as locally governed organisations that generate, manage, or supply energy to deliver community and environmental benefit, they represent one of the more visible expressions of grassroots participation in energy transitions (Seyfang et al., 2013; Braunholtz-Speight et al., 2018). At their most ambitious, they serve as vehicles for decarbonisation, local economic development, fuel-poverty alleviation, and democratic energy governance. Yet the record of UK community energy is conspicuously uneven. Despite sharing a broadly similar policy and regulatory environment, community energy organisations have

followed divergent trajectories: some have grown their asset base, diversified into new service areas, and deepened their local institutional embeddedness, while others have narrowed their scope, become dependent on a single revenue stream, or ceased operations entirely in the wake of policy disruptions such as the removal of feed-in tariff support.

This pattern of divergence within similar institutional conditions constitutes the motivating empirical puzzle of this paper. If organisations face comparable external pressures, why do their trajectories differ so markedly? Existing scholarship offers important but partial explanations. Research grounded in niche theory, transitions governance, and institutional analysis identifies the structural conditions that shape community energy, including policy design, market rules, regulatory frameworks, and broader governance arrangements. These accounts illuminate the terrain within which community energy organisations operate. However, they are less systematic in explaining how organisations and the entrepreneurial actors within them interpret those conditions, position themselves within contested fields, and act strategically over time. This gap is particularly significant because it leaves the sources of within-context divergence analytically underspecified.

This paper aims to develop a clearer conceptual framework for understanding entrepreneurial agency in community energy by bringing foundational entrepreneurial agency scholarship into dialogue with Strategic Action Field (SAF) theory and institutional work. The paper does not aim to resolve the full empirical puzzle of divergence; that is the task of the broader doctoral project of which it forms a part. Rather, it builds the conceptual and theoretical foundations necessary for a systematic empirical investigation. It argues that entrepreneurial agency is an analytically important but insufficiently integrated construct in community energy scholarship, and that its integration with SAF theory and institutional work offers a more complete and field-sensitive framework for understanding how and why community energy organisations follow different paths.

The paper proceeds as follows. Section 2 establishes community energy as a distinctive organisational and institutional phenomenon. Section 3 reviews structural and institutional explanations of community energy, identifying what they explain well and what they leave underspecified. Section 4 introduces the foundational entrepreneurial agency scholarship, establishing conceptual legitimacy for the construct. Section 5 examines how agency is treated in community energy research, arguing that it appears through proxy discussions without sufficient integration. Section 6 develops an integrated conceptual framework drawing on SAF theory and institutional work. Section 7 describes the research orientation of the wider doctoral project. Sections 8 and 9 discuss contributions and conclusions.

2. Community Energy as an Organisational Phenomenon

Community energy is a broad and institutionally contested category. In the UK context, it encompasses a range of organisational forms that share a commitment to local ownership, community governance, and the delivery of energy-related services and benefits. These include community benefit societies, cooperatives, charitable trusts, and hybrid structures that combine elements of social enterprise and community organisation (Walker and Devine-Wright, 2008; Roberts et al., 2014). This organisational diversity is not merely taxonomic; it reflects

genuinely different logics of governance, accountability, and purpose that shape how organisations relate to markets, regulators, and their communities.

What distinguishes community energy organisations from other actors in the energy sector is their hybrid character. They operate simultaneously within civic, democratic, and market-facing logics, and the tensions between these logics are not incidental but structurally constitutive of the organisational form. A community benefit society generating solar energy, for example, must satisfy the expectations of its member-owners, maintain regulatory compliance with the Financial Conduct Authority and Ofgem, negotiate planning and grid-connection constraints, and sustain the social legitimacy that distinguishes it from commercial developers in the eyes of its community. These demands are frequently in tension, and the capacity to navigate them is central to organisational survival.

The scale of UK community energy has grown considerably since the early 2000s, accelerated by the availability of feed-in tariffs from 2010 and by the emergence of sector intermediaries, notably Community Energy England and Community Energy Wales, which play important roles in advocacy, knowledge diffusion, and governance. At its peak, the sector comprised several hundred organisations generating renewable electricity, delivering energy efficiency programmes, and experimenting with new models of local energy supply and demand management (Community Energy England, 2020). However, the removal of feed-in tariff support from community projects in 2016, combined with subsequent changes to planning policy and grid access rules, produced a severe and differentiating shock to the sector. The aftermath has been instructive precisely because it revealed divergence: organisations with similar starting positions responded differently, with some proving more resilient and adaptive than others.

Community energy organisations, therefore, matter organisationally not simply as conduits for renewable energy deployment, but as sites where civic governance, institutional entrepreneurship, and market engagement intersect under contested conditions. They are, in the terminology developed later in this paper, challenger organisations within a field dominated by incumbent energy utilities and a governance structure shaped by state regulation and market rules. Understanding them requires an analytical framework that is attentive to both field structure and the strategic, purposive action of the organisations and actors within them.

3. Structural and Institutional Explanations of Community Energy

The community energy literature has developed sophisticated accounts of the structural and institutional conditions that shape the sector. Three main streams of scholarship are particularly relevant: sustainability transitions research, socio-technical niche analysis, and governance and institutional approaches.

Sustainability transitions research, particularly in its multi-level perspective formulation (Geels, 2002), situates community energy as a niche-level innovation operating at the margins of an incumbent energy regime. Community energy organisations, on this account, are grassroots innovations that experiment with new socio-technical configurations, develop capabilities, and accumulate legitimacy in protected niche spaces, potentially contributing over

time to regime-level change (Seyfang and Smith, 2007; Hargreaves et al., 2013). This framework has proved valuable for explaining the systemic conditions that alternately enable and constrain community energy: the degree of regime stability, the availability of policy protection, and the openness of incumbent actors to new entrants. However, the multi-level perspective has been criticised for offering an under-theorised account of agency, tending to treat actors as relatively undifferentiated carriers of niche or regime logics rather than as strategically situated actors who interpret and enact their conditions differently (Shove and Walker, 2007; Geels, 2014).

Socio-technical niche analysis has generated rich empirical accounts of how community energy organisations emerge, develop, and encounter barriers (Seyfang et al., 2013; Hielscher et al., 2013). This work documents the importance of learning processes, actor networks, and expectational dynamics within niches. It identifies the role of intermediaries in knowledge transfer and capacity building, and it has begun to examine how niches relate to the wider governance environment. More recently, scholars applying SAF theory to sustainability transitions have brought a more explicitly field-structural approach, examining how actors are positioned within organisational fields and how field dynamics shape the possibilities for innovation (Fuenfschilling and Truffer, 2016). This application of SAF theory represents an important development, though it has tended to focus on field-level dynamics more than on the entrepreneurial agency of particular organisations or actors within those fields.

Governance and institutional approaches have examined community energy through the lens of policy design, regulatory frameworks, and local governance arrangements (Hvelplund, 2006; Wierling et al., 2018). This work shows how the institutional architecture of national energy systems shapes what community energy organisations can do, how they are legitimated, and what resources they can access. In the UK context, it has documented how changes to feed-in tariff policy, planning rules, and grid access regimes have restructured the opportunity landscape for community energy (Braunholtz-Speight et al., 2018). It has also examined how devolved governance in Scotland has produced a somewhat different institutional environment from England and Wales, contributing to a degree of cross-national variation in community energy development.

Taken together, these streams of scholarship offer a substantial account of the structural and institutional conditions that shape community energy. They explain why the sector emerged when it did, why it has been concentrated in particular technologies and geographies, and why major policy disruptions have had such significant effects. What they explain less well, however, is why organisations operating within the same broad institutional conditions have followed different trajectories. The multi-level perspective and niche analysis operate primarily at the system or niche level, and while they acknowledge the role of actors, they do not offer a systematic account of how organisations differ in their strategic interpretation and response to shared conditions. Governance approaches similarly focus on the conditions of action rather than on the processes of action itself. The result is an explanatory gap at the level of the organisation and the actors within it: a gap concerning entrepreneurial agency.

4. Entrepreneurial Agency: Foundational Scholarship and Conceptual Building Blocks

Entrepreneurial agency is not an absent or underdeveloped concept in the broader scholarship. It has important theoretical foundations that need to be engaged seriously before the question of its integration into community energy research can be addressed properly.

The foundational tension in theorising entrepreneurial agency derives from what Seo and Creed (2002) characterised as the paradox of embedded agency: how can actors who are shaped by and embedded within institutional arrangements also act upon and transform those arrangements? This tension was introduced into institutional theory by DiMaggio (1988), who identified institutional entrepreneurs as actors motivated to alter institutional structures and possessing the resources to do so. DiMaggio's intervention was significant because it introduced purposive, interest-driven agency into an institutional framework that had tended to explain stability and conformity rather than change and divergence. The paradox, as Seo and Creed (2002) articulate it, is not simply empirical but philosophical: if institutions truly constitute the categories through which actors perceive reality, how can actors stand outside them sufficiently to critique and transform them? Their resolution draws on a dialectical account, arguing that contradictions and tensions within and between institutional arrangements create the conditions under which embedded actors develop the motivation and capacity for critical reflection and divergent action.

McMullen, Brownell, and Adams (2021) represent perhaps the most ambitious recent attempt to develop a unified theory of entrepreneurial agency. Working across eight distinct subcommunities of entrepreneurship research, they identify five elements common to all: ability, motivation, opportunity, institutions, and process. Entrepreneurship, on their account, is best understood as structural transformation, and entrepreneurial agency as the capacity to effect such transformation through purposeful action that works through and upon the structural conditions that simultaneously enable and constrain it. This framework is significant for several reasons. First, it resists the individualistic, trait-based accounts of entrepreneurship that equate agency with talent or psychological disposition. Second, it foregrounds the role of institutional context as both an enabler and a constraint, and it identifies process skills, the capacity to navigate and sustain effort across the temporal trajectory of transformation, as a distinct and analytically important element. Third, by developing a framework that travels across different entrepreneurship subcommunities, it offers a conceptual vocabulary that can, in principle, be applied to new empirical domains, including community energy.

Refai et al. (2025) extend this foundational work by examining entrepreneurial agency specifically in constrained contexts. Their contribution to a special issue of the International Small Business Journal proposes three complementary analytical perspectives: agency in constrained contexts, examining how structural constraints shape what actors can do; constrained positions in context, examining how positional location within a field shapes the form and scope of agency; and interpretations and enactments of constraints, examining how actors' own meanings and framings shape their experience of and response to constraint. This tripartite framework is notable for its recognition that entrepreneurial agency cannot be reduced to individual heroism or generic leadership, but is conditioned by position, interpreted through

meaning, and enacted through specific practices. It also explicitly calls for more empirical research on the interpretation and enactment of constraints, a call that is directly relevant to the community energy context.

Alongside these foundational works, three further bodies of scholarship provide essential conceptual building blocks. Battilana, Leca, and Boxenbaum (2009) develop a process model of institutional entrepreneurship that specifies the conditions under which actors initiate and implement divergent institutional change. They argue that institutional entrepreneurs must not only initiate divergent changes, departing from existing institutional templates, but also actively participate in their implementation. Crucially, field position matters: actors in peripheral or bridging positions often have both the motivation and the structural freedom to challenge incumbent arrangements in ways that more central actors cannot. Fligstein's (1997, 2001) concept of social skill provides a further micro-foundational mechanism. Socially skilled actors are relationally competent: they can read situations, motivate cooperation, build coalitions, and frame shared meanings in ways that advance their projects within contested fields. Social skill prevents entrepreneurial agency from being reduced to rational calculation and keeps the relational, field-conditioned character of action central to the analysis. Finally, Lawrence and Phillips (2019) extend institutional work into what they term social-symbolic work, the purposeful, reflexive efforts of actors to shape both themselves and their circumstances through legitimacy work, temporal work, and relational work. These concepts provide a fine-grained vocabulary for the analysis of how entrepreneurial actors engage with institutional conditions in practice.

Taken together, this body of scholarship establishes entrepreneurial agency as an analytically serious construct with genuine conceptual depth. It is not a simple synonym for individual leadership, and it is not merely a label for the activities of commercially motivated founders. It is a relational, field-conditioned, and enactment-based capacity that is simultaneously enabled and constrained by institutional context, and that is exercised through specific practices, interpretations, and forms of relational work. The question, therefore, is not whether entrepreneurial agency is conceptually legitimate, but whether it has been adequately integrated into community energy scholarship.

5. The Fragmented Treatment of Agency in Community Energy Scholarship

Community energy scholarship does not ignore agency. On the contrary, themes of leadership, capacity, participation, collective action, institutional entrepreneurship, and organisational innovation appear extensively across the literature. The problem is not absence but fragmentation: agency is addressed through a series of relatively disconnected proxy discussions that are not integrated into a coherent, field-sensitive account capable of explaining divergent trajectories.

Leadership and organisational capacity have received sustained attention, particularly in practitioner-facing and policy-oriented literature. Research has documented the importance of founding individuals, key organisational members, and the social networks they mobilise in establishing and sustaining community energy projects (Walker et al., 2010; Seyfang et al.,

2013). This work is valuable in highlighting that organisations do not simply emerge from favourable structural conditions but require active effort and skill. However, it tends to treat leadership as a variable, present or absent, strong or weak, rather than as a theoretically grounded construct that can be analysed in relation to field position, institutional work, and strategic interpretation. Leadership thus functions descriptively rather than analytically.

Participation and collective action provide a second proxy strand. A significant body of research examines the conditions under which communities mobilise around energy projects, the processes through which democratic governance is constructed and sustained, and the challenges of maintaining member engagement over time (Bauwens and Devine-Wright, 2018; Bomberg and McEwen, 2012). This work draws productively on social movement theory, collective action frameworks, and deliberative democracy scholarship. It illuminates the relational and motivational dimensions of community energy in ways that more structuralist accounts miss. However, participation research tends to focus on the creation and maintenance of community engagement rather than on the strategic, institutional, and field-level dimensions of organisational action.

A third element concerns organisational innovation and experimentation. Community energy organisations are frequently presented as sites of social innovation, experimenting with new business models, governance arrangements, and energy services (Hargreaves et al., 2013; Nolden, 2013). This work identifies the adaptive and creative dimensions of community energy practice and locates them within broader accounts of niche development and grassroots innovation. Yet it tends to treat innovation as a feature of niches or communities of practice rather than as an expression of entrepreneurial agency within a structured and contested organisational field.

Perhaps the closest proxy to an explicit engagement with entrepreneurial agency is the concept of institutional entrepreneurship as applied to community energy and energy transitions more broadly (Fuenfschilling and Truffer, 2016; Van Doren et al., 2020). This component explicitly addresses how actors seek to reshape institutional arrangements, and it draws on foundational institutional entrepreneurship scholarship. However, its application in the community energy literature has tended to focus on field-level or system-level change rather than on the organisational level at which divergent trajectories are most clearly visible. Moreover, it has not been systematically integrated with the foundational entrepreneurial agency scholarship of McMullen et al. (2021) or the constrained contexts perspective of Refai et al. (2025).

The cumulative effect of these proxy discussions is a literature that is rich in empirical observation but analytically under-integrated at precisely the point where integration matters most: the explanation of why community energy organisations within similar institutional conditions follow different paths. Each proxy strand captures something real and important, but none of them, individually or collectively, provides a framework that connects the structural dimensions of the field, the positional differences between organisations, the interpretive processes through which actors make sense of their constraints, and the purposive practices through which they act upon those constraints. This is the gap that the present paper addresses.

6. Towards an Integrated Conceptual Framework

6.1 Strategic Action Field Theory: Structural Architecture

Strategic Action Field theory, developed by Fligstein and McAdam (2011, 2012), provides the structural architecture of the proposed framework. A strategic action field is a meso-level social order in which actors are attuned to and interact with one another on the basis of shared, though not necessarily consensual, understandings about the purposes of the field, the relationships within it, and the rules governing legitimate action. Fields are socially constructed arenas in which actors with varying resource endowments compete for advantage, and they are always simultaneously structured and contested.

SAF theory distinguishes among three types of actors. Incumbents are those who exercise dominant influence within the field and whose interests are served by the existing field order; they typically act to reproduce and defend that order. Challengers occupy subordinate positions and receive a smaller share of field benefits; they may seek to contest incumbent arrangements or to develop alternative strategies for navigating the field. Governance units regulate field activity, monitor compliance with field rules, and adjudicate disputes among actors. Fields do not exist in isolation but are embedded within a broader field environment, comprising other fields whose dynamics shape the conditions within which a given field operates.

Fields are not static. Exogenous shocks, whether policy changes, technological disruptions, or crises in adjacent fields, can destabilise existing arrangements, unsettle incumbent positions, and create opportunities for challengers to contest the field order. These episodes of contention may result in either a return to a previous settlement, the emergence of a new configuration, or a prolonged state of instability. The concept of social skill is central to understanding how actors navigate episodes of contention. Socially skilled actors are those who can read field dynamics, motivate cooperation from others, build coalitions, and frame shared interpretations of what is at stake in ways that advance their position within the field.

Applied to UK community energy, SAF theory yields a structured account of the field that illuminates the conditions within which divergent trajectories emerge. Community energy organisations occupy challenger positions within a field dominated by large incumbent energy utilities and shaped by state governance through Ofgem, the Department for Energy Security and Net Zero, and associated regulatory bodies. Sector intermediaries such as Community Energy England and Community Energy Wales function as governance units that regulate membership, adjudicate standards, and mediate between the community energy sector and state actors. The repeated disruptions of feed-in tariff arrangements from 2016 onwards represent field shocks that destabilised the existing settlement, reduced the resource base available to challengers, and created conditions in which organisational differentiation became both more necessary and more visible. Crucially, SAF theory directs analytical attention not only to these structural conditions but also to how actors within them perceive their positions, interpret the rules of the game, and exercise social skill in navigating and contesting field arrangements.

6.2 Institutional Work: Purposive Action within and upon Institutions

SAF theory identifies field structure and the positions of actors within it, but it requires supplementation by a framework that specifies how actors act upon institutional arrangements in detail. Institutional work, as defined by Lawrence and Suddaby (2006), provides this vocabulary. Institutional work refers to the purposive action of individuals and organisations aimed at creating, maintaining, and disrupting institutions. Creating work encompasses practices such as advocacy, defining new norms and standards, constructing normative networks, and building legitimacy for new institutional arrangements. Maintaining work encompasses practices such as policing compliance, valorising existing rules, and routinising accepted practices. Disrupting work encompasses practices aimed at undermining the assumptions on which existing arrangements rest and disconnecting sanctions from non-compliant behaviour.

For community energy organisations, the institutional work perspective directs attention to the specific practices through which they engage with the field: the advocacy work of building legitimacy with local authorities and planning bodies; the maintaining work of sustaining cooperative governance structures and member engagement; and the disrupting work of challenging incumbent energy market rules, contesting planning decisions, or advocating for regulatory change. This vocabulary is analytically more precise than generic references to leadership or capacity, and it connects organisational practices directly to field-level outcomes, including the divergent trajectories that are the central empirical puzzle of the broader doctoral project.

Lawrence and Phillips (2019) extend this framework through their concept of social-symbolic work, which they characterise as the purposeful, reflexive efforts of actors to shape both themselves and their circumstances. Their elaboration of legitimacy work, temporal work, and relational work provides a fine-grained set of analytical categories for examining how entrepreneurial actors within community energy organisations interpret their institutional environment and act upon it. Legitimacy work concerns the efforts of actors to construct and sustain credibility with key audiences, including communities, funders, regulators, and the broader public. Temporal work concerns how actors manage the relationship between past, present, and anticipated futures in their strategic reasoning, sustaining a sense of organisational direction and purpose under conditions of uncertainty. Relational work concerns the ongoing cultivation of alliances, partnerships, and networks that enable organisations to access resources and build the coalitions necessary for action.

6.3 Defining Entrepreneurial Agency for Community Energy

Drawing on the foundational scholarship reviewed above, this paper offers a working definition of entrepreneurial agency for community energy as follows: entrepreneurial agency is the power to create, transform, or influence social and organisational structures through purposeful, contextually embedded action (after McMullen et al., 2021). This definition carries four essential properties that distinguish it from more familiar but analytically weaker formulations.

First, entrepreneurial agency is relational and field-conditioned. It is not a trait held by exceptional individuals but a capacity exercised in relation to fields, institutions, and other

actors. The form, scope, and outcomes of entrepreneurial agency are shaped by the field position of the actor, the resources available to them, and the specific institutional arrangements they navigate (Refai et al., 2025). This means that two actors with similar personal capacities may exercise agency very differently depending on their positional location within the field. An organisation at the centre of a well-resourced network of sector intermediaries and local government partners exercises agency differently from one operating in a peripheral position with limited alliances, even if both operate within the same broad institutional environment.

Second, entrepreneurial agency is enacted rather than merely possessed. It is exercised through specific practices, interpretations, decisions, and relationships, not held as a fixed attribute. The institutional work and social-symbolic work frameworks are essential here because they provide the vocabulary for specifying what enacted agency looks like in practice. Advocacy, coalition-building, legitimacy work, temporal framing, and relational investment are not abstract capacities but concrete practices through which entrepreneurial agency is expressed and sustained.

Third, entrepreneurial agency is simultaneously constrained and enabled by institutional context. Actors do not operate outside or above their institutional environment; they work through and upon it. This is the insight of Seo and Creed (2002) and Battilana et al. (2009), and it is directly applicable to community energy. The same regulatory change that closes off one avenue of action may open another. The same field shock that destabilises incumbent arrangements may create space for challenger repositioning. The analytical task is not to identify whether agency exists, but to specify how it is enacted under particular field conditions, and why different actors enact it differently.

Fourth, entrepreneurial agency in community energy is organisationally situated. The principal unit of analysis in this framework is the community energy organisation, understood as a collective actor that navigates the field through the actions of the individuals embedded within it. The entrepreneurial actors, founders, directors, and strategic leaders who exercise social skill and enact institutional work are always analysed in relation to their organisational position, their field location, and the relational networks through which they act. This prevents the analysis from sliding into heroic individualism and keeps the relational, organisational, and field dimensions of agency constantly in view (Battilana et al., 2009; Fligstein and McAdam, 2012).

6.4 Connecting the Framework to Divergent Trajectories

The integrated framework enables a more theoretically grounded account of divergent trajectories than existing proxy discussions provide. Within the SAF framework, community energy organisations occupy different positions, with different resources, alliances, and relationships to governance units. These positional differences shape the forms of institutional work available to them and the interpretations of constraint that guide their action. A well-positioned organisation with established relationships to local authorities, sector intermediaries, and community stakeholders has a different set of institutional work options than one that is isolated, volunteer-dependent, and lacking in external alliances.

Social skills connect the field structure to actor-level action. Socially skilled actors within community energy organisations can read field dynamics, identify moments of potential contention and coalition-building, and frame their organisations' purposes and contributions in ways that attract cooperation and sustain legitimacy. The concept prevents an account of divergence that rests purely on structural advantage, since socially skilled actors can sometimes shift their positional disadvantages through effective coalition-building and reframing. At the same time, it does not collapse the analysis into pure voluntarism: social skill is exercised within field conditions that set real limits on what is possible and that distribute opportunities unevenly across incumbent and challenger positions.

Institutional work, finally, provides the vocabulary for understanding the specific practices through which divergent trajectories are produced. Organisations that sustain and adapt over time are likely to engage in different patterns of creating, maintaining, and disrupting institutional work than those that narrow or fail. Some may concentrate their institutional work in advocacy and legitimacy-building, constructing new relationships with local authorities and funders; others may focus on maintaining existing arrangements, routinising cooperative governance, and sustaining member engagement. Still others may engage in disrupting work, challenging planning decisions, contesting energy market rules, or advocating for regulatory change. The specific combination of institutional work that a given organisation pursues, and the degree to which that combination fits the field conditions it faces, shapes the trajectory that emerges over time. This argument is analytically richer than the claim that some organisations have better leadership, or that some communities are more engaged, because it connects observable practices to field conditions and to institutional outcomes.

7. Research Orientation

The conceptual framework developed in this paper forms the foundation for a broader doctoral investigation of entrepreneurial agency and divergent trajectories in UK community energy. The research employs a qualitative, multi-level, three-paper design grounded in an interpretivist, social constructivist ontological and epistemological stance, which is consistent with both SAF theory and institutional work as frameworks that treat social reality as constructed through ongoing action, interpretation, and interaction.

The first paper maps the structure of the UK community energy field using qualitative documentary analysis of policy documents, regulatory texts, and sector publications, deploying SAF as an empirical analytical instrument to identify actor positions, governance arrangements, and major field shocks. The second paper employs comparative qualitative case study analysis of approximately four to six UK community energy organisations, selected purposively to maximise contrast in organisational trajectory, examining how differences in institutional work and field position produce divergent outcomes. The third paper focuses on entrepreneurial actors within the case organisations, drawing on semi-structured interview data to examine how actors interpret field conditions, exercise social skill, and enact agency through legitimacy work, temporal work, and relational strategy. Together, the three papers build a cumulative, multi-level explanation that moves from field structure to organisational trajectories, to actor-level agency.

8. Discussion and Contribution

This paper makes four interconnected contributions. The first is to community energy scholarship. Existing research explains the structural and institutional conditions shaping the sector with considerable sophistication, but it does not offer a systematic account of how organisations act within those conditions in ways that produce divergent trajectories. This paper addresses that gap by developing an integrated, field-sensitive framework centred on entrepreneurial agency as an enacted and relational capacity. It reorients the analytical focus from conditions to action, from the field environment to the organisational level, and from structural explanations to explanations that incorporate purposive practice.

The second contribution is to entrepreneurial agency scholarship. McMullen et al. (2021) and Refai et al. (2025) have established important foundations for a unified and contextually grounded theory of entrepreneurial agency. This paper extends their work by applying and developing it in a specific organisational domain, community energy, that raises distinctive analytical challenges. Community energy organisations are not commercial ventures in any conventional sense; they combine civic purpose, democratic governance, and market-facing activity in ways that test and enrich the conceptual vocabulary of entrepreneurial agency. The paper shows how the five elements of entrepreneurial agency identified by McMullen et al. (2021) and the three perspectives of Refai et al. (2025) can be operationalised within an institutional field setting, contributing to the development of a more granular and empirically applicable theory.

The third contribution is to institutional theory. The paper demonstrates that SAF theory and institutional work are complementary rather than competing frameworks, and that their integration offers analytical resources that neither provides alone. SAF theory specifies the field structure within which actors are positioned and identifies the dynamics of incumbent and challenger relations, field shocks, and episodes of contention. Institutional work specifies the practices through which actors engage with that structure, providing a vocabulary for the analysis of creating, maintaining, and disrupting practices at the organisational level. The integration of these frameworks, mediated by the concept of entrepreneurial agency, produces an account of field-conditioned agency that is both structurally informed and practice-attentive.

The fourth contribution is to energy transitions research. Community energy is increasingly recognised as a significant but vulnerable component of energy transitions, and the question of what determines organisational survival and adaptation has important policy implications. This paper suggests that explanations focused solely on structural conditions, policy design, or market rules are insufficient to explain the divergent outcomes observed within the UK community energy sector. Entrepreneurial agency, understood as embedded, relational, and enacted through institutional work within contested fields, is a necessary part of the explanation. This has implications for how support for community energy is designed and delivered, pointing to the importance of building the institutional work capacities and field positioning of community energy organisations, not merely the financial and technical conditions that structural accounts emphasise.

9. Conclusion

This paper began with a puzzle: why do community energy organisations operating within broadly similar institutional conditions follow markedly different trajectories? Existing scholarship explains the structural and institutional terrain well but leaves the sources of within-context divergence analytically underspecified. Agency appears in the community energy literature through a series of proxy discussions, but these remain fragmented and insufficiently integrated with field-structural and institutional accounts.

The paper has argued that entrepreneurial agency has important foundational building blocks in the broader scholarship, established most clearly by McMullen et al. (2021) and Refai et al. (2025), but that these foundations have not been adequately integrated into community energy research. Drawing on SAF theory and institutional work as complementary frameworks, the paper has developed an integrated conceptual framework that understands entrepreneurial agency in community energy as embedded, relational, and enacted within contested fields through purposive institutional work. This framework connects field structure to organisational practice through the mediating concepts of social skill, institutional work, and social-symbolic work, and it provides a more theoretically grounded and analytically precise basis for investigating divergent trajectories than proxy discussions of leadership or capacity can supply.

The framework developed here is not the final word on entrepreneurial agency in community energy; it is a conceptual foundation for the empirical investigation that follows. Its value lies not in resolving the puzzle of divergence but in establishing the analytical vocabulary and theoretical architecture necessary to investigate it systematically. The broader doctoral project will test and refine this framework through qualitative empirical work in the UK community energy field, contributing to a more complete, multi-level understanding of how community energy organisations enact agency within contested institutional environments and why this matters for energy transitions.

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