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STRUCTURING INTERMEDIARY ROLES IN INNOVATION POLICY MIXES:
A MULTI-COUNTRY POLICY-LEVEL ANALYSIS OF COORDINATION AND
PERFORMANCE

Master's Thesis

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I, Xuhua Huang, hereby declare that I have completed this Master's Thesis independently. All ideas, data, and sources used have been properly acknowledged and referenced.

Table of Contents

Introduction.....	4
Literature Review.....	9
2.1 Structural Roles of Innovation Intermediaries in National Innovation Systems	10
2.2 Structural Composition and Role Construction in Innovation Policy Mixes	12
2.2.1 From Instrument Combinations to Institutional Architectures	12
2.2.2 Role Construction Through Target-Theme Configurations	13
2.2.3 Policy Mixes as Structural Identification Tools.....	14
2.3 Innovation Performance: A Structural Perspective	15
2.3.1 Innovation Performance as a Structural Reflection	15
2.3.2 Intermediary Positioning and Systemic Coherence	16
2.3.3 The Global Innovation Index as a Structural Proxy.....	16
Analytical Framework	17
3.1 From Policy Structure to System Outcome: Mechanism-Based Explanation	17
3.2 Structurally Configured Roles as Institutional Mechanisms	18
3.3 Mechanism Diversity and Structural Role Configurations.....	19
3.4 Empirical Operationalization and Strategy.....	19
Methodology	21
4.1 Data Sources	21
4.2 Key Variables	23
4.2.1 Policy Mix Structure	23
4.2.2 Innovation Performance.....	25
4.3 Empirical Strategy	27
4.4 Regression Models.....	29
Result	31
5.1 Descriptive Patterns of Intermediary-Based Policy Mixes.....	31
5.2 Descriptive Statistics and Variable Correlations.....	33

5.3 Regression Analysis	35
5.3.1 Mix 1: System-Integrated Configuration as a Response to Institutional Fragmentation	41
5.3.2 Mix 2: Issue-specific coordination as a capability-aligned policy structure.....	43
5.3.3 Mix 3: Research-centric embedding as an internally reinforced policy structure ..	46
5.3.4 Mix 4: Institutional exclusion and centralized emergence without intermediaries	48
Heterogeneity Analysis	52
6.1 Formation Across Innovation Capacity Levels.....	52
6.2 Performance Effects Under Institutional Regimes	57
Discussion.....	62
Conclusion and Future Research	64
List of references.....	66
Appendices.....	77
Appendix A.....	77
Appendix B.....	79
Appendix C.....	80
Appendix D.....	81
Appendix E	83

Introduction

In recent decades, national innovation policy has evolved from isolated, interventionist approaches to complex and multi-level systems of governance (Magro & Wilson, 2013). As innovation systems have become increasingly interdependent and dynamic, the coordination of diverse institutional actors including governments, firms, universities, and civil society has emerged as a central concern in policy design (Edquist, 2006; B. Lundvall, 2007). This issue is particularly salient in the context of grand societal challenges, such as climate transition and digitalisation, which demand distributed coordination across fragmented governance domains. In this context, innovation intermediaries have received growing attention as policy-relevant actors that help address systemic coordination failures within innovation systems (Howells, 2006; Weber & Rohracher, 2012). The rationale for their involvement lies in their capacity to facilitate knowledge circulation, bridge institutional and sectoral divides, and support collective learning processes across heterogeneous actors (Caloffi et al., 2023; Howells, 2006). However, the mere presence of such actors does not guarantee effective system coordination, as their contribution depends critically on how they are institutionally embedded, legitimized, and supported within broader policy and governance frameworks (Edler & Boon, 2018; Kuhlmann & Rip, 2018; OECD, 2011; Uyarra, 2010). In particular, the architecture of policy mixes has become a crucial site through which coordination capacities are constructed and distributed, reflecting not just an aggregation of instruments but a structured governance framework with embedded assumptions about roles and responsibilities (Flanagan & Uyarra, 2016; Magro & Wilson, 2013; Rogge & Reichardt, 2016). Beyond instrument diversity, policy mixes encode assumptions about agency, responsibility, and alignment, thereby shaping how actor roles are allocated and embedded in governance structures (Flanagan & Uyarra, 2016; Rogge & Reichardt, 2016). Yet, how intermediaries are structurally positioned within individual policy instruments and their configurations remains conceptually underexplored, despite their increasing policy relevance and institutional salience (Borrás & Edquist, 2013; Kuhlmann & Rip, 2018; OECD, 2011).

While the importance of innovation intermediaries is widely acknowledged, existing research has predominantly conceptualized them in terms of their organizational form and observable activities, often distinguishing intermediaries based on whether intermediation is their core function or a secondary by-product (Klerkx & Leeuwis, 2009; Winch & Courtney,

2007). Much of this literature focuses on identifying which types of organizations act as intermediaries, including incubators, industry associations, technology transfer offices, academic societies, and non-governmental organizations, and describing their roles in brokering, knowledge exchange, or platform building (Caloffi et al., 2023; Howells, 2006). Although this work has advanced our understanding of intermediary contributions to innovation processes, it has paid limited attention to how such roles are constructed, allocated, and legitimized through formal policy design (Edler & Boon, 2018; Kuhlmann & Rip, 2018). This conceptual gap is significant, as intermediaries cannot meaningfully contribute to system-wide coordination unless they are institutionally recognized, granted mandate, and embedded in governance structures (OECD, 2011; Uyerra, 2010).

Understanding how intermediary roles are constructed and sustained requires attention to the institutional frameworks through which innovation systems allocate coordination responsibilities. Recent policy mix literature has increasingly shifted from an emphasis on instrument diversity to concerns with structural coherence, institutional alignment, and the distribution of governance functions (Flanagan & Uyerra, 2016; Magro & Wilson, 2013; Rogge & Reichardt, 2016). Policy mixes are thereby conceptualized not merely as collections of instruments but as patterned configurations that reflect assumptions about actor roles, systemic interaction, and strategic intent (Flanagan & Uyerra, 2016; Rogge & Reichardt, 2016). Despite this shift, limited research has addressed how these structural features relate to intermediary actors. Existing studies seldom consider how coordination mandates are assigned to intermediaries or how policy instruments define their institutional position and systemic relevance (Edler & Boon, 2018; Kuhlmann & Rip, 2018). As a consequence, the structural role of intermediaries as embedded within individual policy instruments and their aggregation into national architectures remains underexamined. This paper contributes to addressing this gap by linking the structural turn in policy mix analysis with a role-based perspective on intermediaries. It investigates how coordination functions are embedded in innovation policy design through the positioning of intermediaries within instrument targeting and thematic structuring. This approach shifts the focus from functional accounts of intermediary activity to the institutional conditions under which intermediary roles are defined and enacted.

Nevertheless, the structural configuration of intermediaries within innovation policy systems remains a conceptually necessary yet underexplored area of inquiry. While intermediaries are widely acknowledged for their role in facilitating collaboration and

knowledge exchange (Caloffi et al., 2023; Howells, 2006), their ability to contribute to system-wide coordination, such as orchestration and cross-sectoral alignment, depends on the extent to which they are institutionally embedded and formally supported within policy design (Edler & Boon, 2018; Kuhlmann & Rip, 2018). Effective coordination, however, depends not on the mere presence of intermediary actors, but on their explicit institutional positioning within policy instruments and governance structures (Flanagan & Uyarra, 2016). This becomes particularly salient as national innovation systems face increasingly complex and cross-cutting challenges, including climate transition and digitalisation, which require distributed coordination across multiple policy domains (Schmidt & Sewerin, 2019). Meeting such demands requires that intermediaries be understood not simply as operational entities, but as structurally embedded governance nodes whose legitimacy depends on institutional visibility and procedural mandate (Rogge & Reichardt, 2016). Without adopting a structural perspective, existing research cannot account for why similar intermediary types succeed in some systems while remaining peripheral in others, nor can it explain how policy designs generate differentiated coordination capacity. Reframing intermediaries as role configurations embedded in policy mixes thus offers not only a corrective to functionally grounded accounts, but also a theoretically grounded lens for analysing how coordination is institutionalised in innovation systems (Uyarra, 2010; Weber & Rohracher, 2012).

Recent literature has emphasized that policy mixes are not simply collections of instruments but structured configurations that reflect underlying governance logics and institutional expectations (Flanagan & Uyarra, 2016; Rogge & Reichardt, 2016). These expectations are reflected in how instruments are aligned with particular target groups and thematic priorities, which in turn reveal assumptions about who is expected to act, on which issues, and with what kind of capacity (Rogge et al., 2017; Russo & Pavone, 2021). In this view, policy mixes function as governance architectures that allocate coordination responsibilities and define actor roles (Borrás & Edquist, 2013). This structural interpretation is particularly relevant for intermediaries, whose influence within innovation systems often derives not from formal authority but from their institutional positioning in national strategies (Edler & Boon, 2018; Kuhlmann & Rip, 2018). When policy instruments explicitly target intermediaries in relation to specific policy themes such as sustainability transitions or entrepreneurial ecosystems, the configuration of instruments reflects how their coordination roles are embedded within the broader policy framework. Empirical studies have recently begun to operationalize policy mix structures by clustering instruments based on their target

groups and thematic content, thereby identifying role-oriented configurations across different governance contexts (Howoldt, 2024; Russo & Pavone, 2021). Extending recent structural approaches to policy mix analysis, this study aims to examine how intermediary roles are constructed and positioned within national innovation policy mixes, and how these structural configurations are associated with patterns of system-level innovation performance. It further analyzes how the structure of policy mixes embeds different intermediary roles and how these configurations relate to system-level outcomes.

This study analyzes 1,049 individual policy instruments adopted between 2013 and 2024 across 54 countries, using data from the OECD STIP Compass and the Global Innovation Index, to examine how intermediary roles are configured within the design of specific STI policy measures. The sample is restricted to measures that explicitly identify innovation intermediaries among their stated target groups, although many of these also reference additional actor categories and thematic domains, allowing for the identification of intermediary-specific coordination structures. A clustering procedure is applied to the co-occurrence of target groups and policy themes within each policy, which in this study jointly define the structural configuration of a policy mix. Through this procedure, four structural role types are derived and assigned as compositional shares to individual policy measures. Among these, three configurations incorporate intermediaries in different institutional positions: one involves formalized actors oriented toward bridging fragmented governance domains, another draws on adaptive organizations linked to specific transformation agendas, and a third confines intermediary activity to research-related functions without broader systemic integration. A fourth configuration consists of policies that omit intermediaries altogether and serves as a comparative reference group. To assess the broader implications of these configurations, each policy measure is linked to structural innovation indicators of the corresponding country and year, allowing for policy-level analysis contextualized within national innovation systems selected from the Global Innovation Index through a two-phase filtering process combining regularization and model-based selection. Rather than functioning as a purely descriptive tool, the clustering procedure operationalizes the assumption that policy mixes encode governance expectations. By examining the structural co-occurrence of actor targets and thematic areas, it reveals how coordination roles are embedded and differentiated across systems. The empirical analysis indicates that policies structurally aligned with issue-specific mixes tend to be associated with higher levels of innovation performance in their respective national contexts, while research-insulated

configurations show a negative relationship. System-integrative and exclusionary mixes display more variable effects, depending on institutional capacity and governance characteristics. These findings suggest that intermediary roles are not interchangeable but are institutionally differentiated through the design of individual policy instruments, with consequences for the systemic coherence and performance of innovation systems.

This study conceptualizes innovation intermediaries as structurally embedded roles within policy systems, rather than predefined organizational forms, thereby shifting the focus from what intermediaries are to how their functions are institutionally constructed. This reframing contributes to a theoretical understanding of coordination in innovation systems by identifying intermediaries not as fixed entities but as positionally defined actors whose relevance is contingent on their alignment within policy architectures. The analysis advances a structural approach to policy mix research by demonstrating how configurations of target groups and thematic goals generate role distributions with systemic consequences. These patterns are operationalized through a two-phase analytical framework that links policy-level coordination structures to country-level innovation performance, capturing both how intermediary-oriented mixes emerge across different national settings and how their effects vary with governance conditions. While this framework contributes to theory-building on the institutional foundations of coordination, it also provides a practical lens for identifying where intermediary roles are weakly embedded or fragmented. By relating structural design to systemic alignment, the study offers a diagnostic tool for enhancing the coherence of innovation strategies in context-sensitive ways.

The remainder of the paper is structured as follows. Section 2 reviews the literature on innovation intermediaries and policy mix structures. Section 3 outlines the analytical framework. Section 4 presents the data, classification strategy, and empirical models. Section 5 reports the main findings. Section 6 presents the heterogeneity analysis. Section 7 discusses theoretical and practical implications. Section 8 concludes with a summary of contributions and suggestions for future research.

Keywords: innovation policy, intermediary organizations, policy mix, governance, coordination

CERCS: S170, S180

Literature Review

While national innovation policy has increasingly moved toward systemic and actor-diverse approaches (Borrás & Edquist, 2013; Edquist, 2006; Flanagan & Uyarra, 2016), the institutional positioning of certain actors within these frameworks, although noted early on, remains underexamined in policy mix research (Edler & Boon, 2018; Kuhlmann & Rip, 2018; Rossi et al., 2022; Van Der Meulen & Rip, 1998).

Over the past decades, innovation has come to be seen not as a linear, isolated process, but as a cumulative outcome of interactive learning and knowledge exchange among organizations, institutions, and individuals (Yawson, 2019). Reflecting this shift in understanding, national innovation policies have moved away from traditional linear models toward a more systemic perspective that emphasizes the complexity of innovation and the diversity of actors involved (Edquist, 2006; B.-Å. Lundvall, 2016). Policy frameworks have been gradually reconfigured to encompass a wider range of stakeholders including academia, industry, government, and the public, thus contributing to the emergence of more inclusive and integrated national innovation ecosystems (Yawson, 2019). Correspondingly, policy makers have begun to focus less on narrowly supporting high-tech firms or R&D activities, and more on shaping the institutional structures, networks, and interactions that underpin the functioning of innovation systems as a whole (B.-Å. Lundvall, 2016).

This paradigmatic shift has directed increasing scholarly attention toward policy design, with a growing emphasis on the process of policy formation and the actors involved in shaping its outcomes (Haelg et al., 2020). These actors include firms, research organizations, individuals, public institutions, and governments (OECD, 2023), as well as an expanding and increasingly heterogeneous set of innovation intermediaries (Caloffi et al., 2023). These intermediaries facilitate coordination, knowledge exchange, and system learning, helping to connect otherwise fragmented or disconnected parts of the innovation ecosystem (Caloffi et al., 2023).

While their practical relevance has been widely acknowledged (Caloffi et al., 2023; De Silva et al., 2018; Howells, 2006b), existing research tends to focus on their operational or network-level functions, often portraying these roles as fixed, technical, or taken for granted (Van Der Meulen & Rip, 1998). What remains underexplored is how these intermediary roles are conceptualized, structured, and embedded within broader policy processes, particularly in relation to how they contribute not only to improving system connectivity but also to

fostering new possibilities and dynamism within innovation systems (Flanagan & Uyarra, 2016; Howells, 2006b).

Recent contributions argue that innovation policy must be seen not merely as a set of tools, but as a structured configuration that embeds assumptions about actors and distributes roles accordingly (Flanagan et al., 2011; Howlett & Rayner, 2007; Rogge & Reichardt, 2016). Extending this perspective, research on policy mix design has highlighted how innovation policies define and shape roles through the integration of instruments, thematic priorities, and embedded expectations about agency (Flanagan et al., 2010). These developments point to the importance of analyzing how intermediary roles are institutionally configured and sustained within policy architectures, and how such configurations acquire systemic relevance. These developments suggest the need to move beyond viewing intermediation as a set of predefined contributions and toward an institutional analysis of how coordination responsibilities are embedded in policy architectures and linked to systemic governance expectations.

2.1 Structural Roles of Innovation Intermediaries in National Innovation Systems

The increasing fragmentation and multi-level character of innovation systems has given rise to new demands for coordination across institutional, sectoral, and territorial boundaries (Borrás & Edquist, 2013; Edquist, 2006; Weber & Rohracher, 2012). As responsibilities for innovation policy become distributed across a wider set of actors and domains, questions of how coordination is achieved beyond hierarchical control or market incentives have gained central importance (Flanagan & Uyarra, 2016; Kuhlmann & Rip, 2018). One institutional response to this challenge has been the rise of innovation intermediaries, which have been positioned as mechanisms for enabling alignment across otherwise disconnected parts of the system.

The literature on innovation intermediaries has predominantly emphasized their functional contributions to innovation processes, including knowledge brokering, collaboration facilitation, and resource mobilization (Hargadon & Fanelli, 2002; Howells, 2006a; Lichtenthaler, 2013). These studies identify intermediaries as knowledge translators, boundary spanners, or platform coordinators operating across different organizational and sectoral contexts (Caloffi et al., 2023; Dalziel, n.d.; Prandelli et al., 2006). While these roles are well documented, the literature has often treated them as intrinsic to specific actor types,

with limited attention to the institutional settings that enable, constrain, or redefine their position within governance structures (Edler & Boon, 2018).

Recent contributions have introduced a structural perspective, emphasizing that the relevance of intermediaries depends on their institutional recognition and embedding within governance arrangements (Kuhlmann & Rip, 2018; Van Der Meulen & Rip, 1998). Their contribution to coordination, learning, or knowledge flows depends not only on what they do but also on how they are positioned within the system's institutional architecture (Edler & Boon, 2018; Flanagan et al., 2011). This perspective shifts the analytical focus from function to position, underscoring the need to examine how intermediary roles are constructed and sustained through institutional design.

Empirical studies show that intermediaries are situated differently across subsystems within national innovation systems. In research and education contexts, they often take the form of university-affiliated entities such as incubators or living labs (Caloffi et al., 2023; Katzy et al., 2013). In industry-facing domains, intermediaries are integrated into sectoral innovation networks and take on roles related to demand articulation or market coordination (Klerkx & Leeuwis, 2009; Smedlund, 2006). Some actors operate across domains, linking policy, academic, and commercial environments (Bakici et al., 2013; Polzin et al., 2016). These patterns suggest that intermediary roles are not uniform but shaped by the subsystem in which they are embedded (Janssen et al., 2020). In some policy environments, intermediaries are absent from formal governance structures altogether. This reflects an implicit reliance on hierarchical or market-based coordination mechanisms, in which no dedicated coordination role is structurally assigned (Borrás & Edquist, 2013; Edler & Boon, 2018).

However, structural roles are often inferred from observable functions or network positions. Few studies investigate how such roles are institutionally constructed or allocated through policy design (Rossi et al., 2022; Smedlund, 2006). The mechanisms by which intermediaries gain visibility and mandate remain underexplored, limiting understanding of how policy systems govern intermediary functions as part of innovation governance (Flanagan & Uyerra, 2016; Kuhlmann & Rip, 2018).

These observations point to the need for a more explicit conceptualization of structure in relation to intermediary roles. In this study, structure is not understood as formal organizational form or mere network position, but as the patterned allocation of coordination tasks, responsibilities, and institutional visibility within governance architectures. Such a

view foregrounds the systemic conditions under which intermediary roles become institutionally viable, highlighting that coordination is not only performed but also configured. This perspective builds on existing accounts of policy design as embedded with assumptions about agency and role assignment (Edler & Boon, 2018; Flanagan et al., 2011; Rogge & Reichardt, 2016), and enables a shift from describing intermediary activity in terms of output behavior to analyzing how coordination responsibilities are structurally assigned and sustained.

A further issue arises from the tendency to conflate actor types with the roles they are expected to perform. When universities, NGOs, or agencies are labeled as intermediaries by default, this risks overlooking the ways in which such roles are institutionally negotiated and shaped through policy design (Edler & Boon, 2018; Van Lente et al., 2003). Clarifying the distinction between organizational identity and system-level role assignment is essential for analyzing how policy mixes structure visibility, authority, and coordination across governance settings (Flanagan & Uyarra, 2016; Van Der Meulen & Rip, 1998). This analytical distinction makes it possible to examine how intermediary roles are not only described but structurally constructed through their placement within policy instruments and thematic configurations.

2.2 Structural Composition and Role Construction in Innovation Policy Mixes

2.2.1 From Instrument Combinations to Institutional Architectures

The concept of policy mix is commonly defined as a deliberate or evolving combination of policy instruments, objectives, and implementation processes designed to influence innovation-related outcomes within a given governance context (Bouma et al., 2019; Flanagan et al., 2011; Rogge & Reichardt, 2016). It encompasses not only the variety of instruments involved but also their intended complementarities, coherence, and institutional embedding. While some accounts treat policy mix as synonymous with instrument mix, referring primarily to the combination of tools (Barton et al., 2009; Bressers & O'Toole, 2005), others distinguish the two by emphasizing multi-level interactions, policy goals across domains, and evolving governance architectures (Del Rio & Howlett, 2013; Kern & Howlett, 2009). More recent perspectives further highlight the procedural and historical dimensions through which policy mixes emerge, often shaped by path dependencies and coordination needs (Bouma et al., 2019; Howlett & Rayner, 2007). This evolution

reflects a shift from a functionalist to a structural-institutional understanding of innovation governance.

Early scholarship on policy mixes emphasized the combination of discrete instruments and the need to ensure their functional alignment and coherence in support of innovation objectives. This approach presumed that innovation outcomes could be optimized through the rational selection and coordination of tools (Flanagan & Uyarra, 2016). However, more recent contributions have highlighted that policy mixes seldom emerge from intentional design alone. Instead, they evolve over time through processes of layering, drift, and institutional sedimentation, resulting in architectures that are shaped as much by historical legacies and political negotiation as by strategic intent (Howlett & Rayner, 2007; Mahoney & Thelen, 2010; Rogge & Reichardt, 2016).

Seen in this light, policy mixes are not simply collections of instruments but institutional arrangements that carry embedded assumptions about how innovation is governed. They reflect implicit preferences regarding actor visibility, coordination responsibilities, and systemic boundaries (Edler & James, 2015; Kemp & Pontoglio, 2011). These assumptions are rarely made explicit but manifest in the distribution of coordination functions, the thematic framing of interventions, and the inclusion or omission of specific actor categories (Flanagan & Uyarra, 2016; Rogge & Reichardt, 2016). Understanding how roles are positioned within policy mixes therefore requires attention to the structural composition of the mix itself.

2.2.2 Role Construction Through Target-Theme Configurations

From a structural perspective, policy designs do not assign roles directly. Instead, coordination functions become visible through recurring linkages between specific actor categories and particular thematic domains, reflecting how institutional routines embed assumptions about who is expected to act, and where (Edler & Boon, 2018; Flanagan & Uyarra, 2016; Kuhlmann & Rip, 2018). These configurations encode assumptions about who is expected to coordinate, under what conditions, and in which policy domains (Rogge et al., 2017). For instance, intermediary organizations that are consistently associated with transformation-oriented themes, such as ecosystem development, may be institutionally positioned as coordinators, while others remain confined to narrowly scoped implementation roles (Edler & Boon, 2018; Flanagan & Uyarra, 2016; Klerkx & Leeuwis, 2009; Rogge & Reichardt, 2016).

Such role expectations are not the product of technical design but reflect institutional path dependencies, administrative routines, and governance traditions that shape how responsibilities are reproduced across contexts (Howlett & Rayner, 2007; Mahoney & Thelen, 2010). Roles thus crystallize not through single instruments but through structured repetition and thematic framing, reinforcing patterns of visibility and influence (Flanagan & Uyarra, 2016; Kergroach et al., 2018). These dynamics are especially relevant for intermediaries, whose coordination functions often lack formal authority and depend on whether the policy mix provides institutional space for their activities to materialize (Kuhlmann & Rip, 2018; Smedlund, 2006).

Several studies have begun to document these differentiated role types. Some actors are positioned as system-wide coordinators through their alignment with cross-cutting strategies (Kuhlmann & Rip, 2018; Rogge & Reichardt, 2016), while others serve as technical agents for narrow objectives (Klerkx & Leeuwis, 2009; Polzin et al., 2016). Still others are structurally peripheral, referenced without meaningful authority or excluded from key coordination functions altogether (Edler & Boon, 2018; Mahoney & Thelen, 2010). These analytical distinctions are fundamental to comprehending the mechanisms through which policy mixes structure and transform the institutional environment of innovation systems.

2.2.3 Policy Mixes as Structural Identification Tools

A structural reading of policy mixes offers an alternative to definitions of actor roles based on formal mandates or organizational form. Instead of relying on formal mandates or self-identification, intermediary roles can be discerned by analyzing how policy mixes systematically connect particular actor categories with distinctive governance themes (Edler & Boon, 2018; Flanagan & Uyarra, 2016). These associations reflect coordination expectations embedded in policy design, revealing how systems anticipate and organize the division of innovation-related tasks (Kuhlmann & Rip, 2018; Rogge et al., 2017).

This analytical perspective is especially crucial in decentralized and layered governance environments where intermediaries function without hierarchical oversight. In these contexts, their institutional significance stems not from official appointment, but rather from how the structure of the policy mix enables their functional and institutional sustainability (Edler & Fagerberg, 2017; Van Lente et al., 2003). Policy mixes that feature dispersed coordination needs and cross-thematic linkages are more likely to contain

structurally embedded space for intermediation to emerge (Flanagan & Uyarra, 2016; Howlett, 2009).

The structure of policy mixes often reflects embedded assumptions about which actor types are expected to coordinate specific policy functions (Edler & Boon, 2018; Flanagan & Uyarra, 2016). These assumptions are rarely stated directly, but can be inferred from repeated associations between actor categories and thematic policy domains. For intermediary actors, whose roles are frequently informal and context-dependent, such associations are particularly indicative of how coordination functions are institutionalized (Smedlund, 2006; Van Lente et al., 2003). By applying clustering to instruments that explicitly reference intermediaries, it becomes possible to identify systematic patterns in how these roles are embedded across national strategies. This approach provides a structural lens for analyzing role configurations and their implications for innovation system governance (Howoldt, 2024).

2.3 Innovation Performance: A Structural Perspective

2.3.1 Innovation Performance as a Structural Reflection

Innovation performance has increasingly been conceptualized not merely as the sum of technological outputs or input efforts, but as a reflection of how national innovation systems are institutionally arranged (Castellacci & Natera, 2013; Edquist, 2011). Within this view, performance is seen as the aggregate result of coordinated knowledge exchange, institutional alignment, and governance coherence (Edler & Boon, 2018; Flanagan & Uyarra, 2016). Coordination capacity is therefore viewed as embedded within governance arrangements rather than as an exogenous condition (Flanagan & Uyarra, 2016). It depends on how roles, responsibilities, and mechanisms for connection are institutionally distributed (Howlett & Rayner, 2007; Rogge & Reichardt, 2016).

Intermediary roles are particularly salient in this framework because they contribute to the connective infrastructure of the system. When intermediaries are formally positioned within policy structures, their ability to foster cross-sectoral integration and system learning is enhanced (Howells, 2006a; Kuhlmann & Rip, 2018). By contrast, where these roles are left informal or are ambiguously embedded, policy frameworks may fail to support coordination even when instrumentally active (Edler & Boon, 2018). From this perspective, national innovation performance can be understood as a structural outcome, shaped by how effectively systems allocate coordination functions and embed intermediary capacities within their institutional configurations.

2.3.2 Intermediary Positioning and Systemic Coherence

Structural differences in the positioning of intermediaries offer an important explanation for the observed variation in innovation outcomes across countries. While some policy mixes place intermediaries in clearly defined roles that span governance levels or thematic domains, others treat them as marginal actors with limited systemic function (Smedlund, 2006; Van Lente et al., 2003). The way intermediary responsibilities are structured reveals the underlying logic of coordination embedded in the policy mix (Edler & Boon, 2018; Flanagan & Uyarra, 2016). Institutional clarity and thematic breadth can enable intermediaries to support coherence across fragmented policy arenas (Flanagan et al., 2011; Polzin et al., 2016).

Conversely, when intermediary roles are narrowly defined or inadequately integrated, governance gaps may persist despite formal policy implementation. Within such contexts, the absence of embedded coordination functions demonstrably compromises system-level performance (Kuhlmann & Rip, 2018). Existing research has pointed out that coherence within innovation systems depends not only on policy alignment but also on the distribution of agency and the visibility of actors tasked with enabling interaction (Edler & Boon, 2018; Flanagan & Uyarra, 2016). In this study, intermediary positioning is conceptualized as an institutional signal of systemic coherence, rather than a technical attribute of organizational behavior.

2.3.3 The Global Innovation Index as a Structural Proxy

To evaluate how intermediary configurations relate to broader patterns of innovation performance, this study adopts the Global Innovation Index (GII), which is widely used in cross-national comparisons of innovation systems (Crespo & Crespo, 2016; WIPO, 2024). The GII aggregates a set of indicators across seven thematic areas. Five of them are categorized as input dimensions, covering institutional quality, human capital, infrastructure, market sophistication, and business environment. The remaining two focus on output performance, including knowledge production and creative activity (WIPO, 2024). This structure enables the index to reflect both the resource base and the institutional arrangements that underpin innovation capacity (Crespo & Crespo, 2016).

The GII is particularly relevant to this study because it provides a basis for comparing countries within the same year, which aligns with the cross-sectional nature of the empirical design (Crespo & Crespo, 2016). It also captures conditions that have already materialized by

the time of measurement, rather than projecting future trends, which makes it suitable for analyzing existing policy configurations (WIPO, 2024). This temporal orientation supports the study's focus on structural roles and their relationship to observed performance outcomes. Moreover, by incorporating both input and output components, the GII allows innovation to be interpreted as a systemic reflection of how governance, coordination, and resource allocation interact within national systems (Castellacci & Natera, 2013; Edler & Fagerberg, 2017).

Although the GII has attracted methodological critique, especially regarding the construction of composite indicators and the weighting of sub-components (Godin, 2014; P. C. Smith & Street, 2005; Yu et al., 2021), it remains a consistent reference point in the evaluation of innovation systems. In the context of this analysis, the GII is not treated as a direct measure of coordination. Instead, it serves as a system-level indicator that can be used to examine whether structurally differentiated roles within policy mixes correspond to differences in national innovation outcomes.

Analytical Framework

This study builds on the understanding that innovation performance reflects the coordinated functioning of institutional structures while also shaping their subsequent evolution (Castellacci & Natera, 2013; Mahoney & Thelen, 2010). The Global Innovation Index, despite its limitations, offers a practical proxy for examining these system-level dynamics. Its multidimensional structure supports a mechanism-based analysis of how the embeddedness of specific actor roles, particularly innovation intermediaries, relates to national innovation outcomes (Edler & Fagerberg, 2017; Rogge & Reichardt, 2016). While previous studies have explored the functional contributions of intermediaries and the compositional design of policy mixes, few have addressed how structurally configured roles within policy systems correspond to cross-national variation in innovation performance. The empirical analysis that follows takes up this question by linking the role configurations identified in policy mixes to observed system-level outcomes across a global sample.

3.1 From Policy Structure to System Outcome: Mechanism-Based Explanation

This study adopts a mechanism-based approach to examine how the structural configurations of individual STI policy instruments shape national innovation performance. Rather than focusing on the direct effects of individual policy instruments, the analysis centers on the institutional mechanisms through which policy mixes construct and assign

roles to actors such as innovation intermediaries. These roles, once embedded in the policy structure, shape the conditions under which system-level coordination, integration, and resource alignment become institutionally possible or constrained. This perspective builds on a view of innovation systems as structured environments in which actor configurations, rather than isolated interventions, constitute the functional basis of system outcomes (Edler & Boon, 2018; Flanagan & Uyarra, 2016; Rogge & Reichardt, 2016). Accordingly, mechanisms are not input-output correlations, but architectures that jointly shape how roles are configured and how system outcomes emerge (Gerring, 2008).

3.2 Structurally Configured Roles as Institutional Mechanisms

The concept of structurally configured roles refers to the positions that actors occupy within a policy architecture, defined by how instruments target specific actor types and associate them with particular innovation functions. In this study, structurally configured roles refer specifically to the functions assigned to intermediary actors through the alignment of policy targets and themes. These roles are treated as institutionalized positions that emerge from the design of policy mixes, rather than as the operational characteristics of individual organizations. This interpretation aligns with the institutionalist perspective that views actor functions as outcomes of policy design, not only as expressions of organizational agency (Flanagan et al., 2011; Kuhlmann & Rip, 2018).

Innovation intermediaries are analytically significant precisely because their institutional presence and influence are contingent on how roles are configured within policy structures. Unlike firms or government agencies with established legal mandates, intermediaries often depend on policy design for their institutional legitimacy and operational scope (Polzin et al., 2016; Smedlund, 2006). Their roles, whether as central coordinators, thematic implementers, or marginal supporters, are shaped by how policy mixes align specific targets with policy themes (Janssen et al., 2020). This alignment determines whether intermediaries can function effectively as system-level enablers of coordination, integration, and transformation (Edler & Boon, 2018; Kuhlmann & Rip, 2018). In this connection, the analysis does not focus on the characteristics of individual organizations but examines role construction through the structural design of individual policy instruments, which collectively reflect broader coordination architectures.

3.3 Mechanism Diversity and Structural Role Configurations

Although structurally configured roles are not statistical variables, they exhibit identifiable patterns that lend themselves to typological analysis. Existing literature suggests that policy mixes tend to embed intermediaries into a limited set of structural roles. Some intermediaries are configured as system-wide coordinators with high centrality in governance networks (Kuhlmann & Rip, 2018). Others serve as thematic service providers tied to specific missions or bounded policy areas (Klerkx & Leeuwis, 2009; Polzin et al., 2016). Still others may be structurally marginalized, either because they lack formal recognition or because they are positioned at the periphery of decision-making processes (Flanagan & Uyarra, 2016).

These configurations reflect underlying governance assumptions about who should act, with whom, and under what institutional authority. By identifying such role typologies, this study aims to examine how different configurations of intermediary roles are associated with national-level innovation outcomes. This approach is consistent with the view that typologies function not as static classifications but as analytically derived configurations that represent meaningful combinations of design elements. Such configurations are understood as causally relevant patterns rather than taxonomic groupings (Fiss, 2011). These role patterns are interpreted as systemic properties of national policy architectures, rather than as ad hoc arrangements. They indicate how governance logics are embedded in the structure of coordination mechanisms. As Schneider and Wagemann (2012) emphasize, configuration-based reasoning enables the identification of limited diversity among possible institutional combinations and supports explanatory inference in small-N comparative research. Such configurations are treated as structured expressions of governance logics embedded in policy design (Flanagan & Uyarra, 2016; Rogge & Reichardt, 2016).

3.4 Empirical Operationalization and Strategy

To investigate how structural role configurations link policy design to system-level innovation outcomes, each centred on cross-national variation in the structural design and implications of individual policy instruments. Rather than tracing within-country changes over time, the analysis compares countries at discrete time points to identify how institutional conditions and policy configurations are systematically associated. The emphasis lies on structural mechanism identification rather than predictive modeling or time-series estimation.

In the first phase, the analysis explores how national innovation system conditions are reflected in the role-based structural compositions of individual STI policy measures.

Drawing on metadata from the OECD's STIP Compass database, the study identifies policy instruments that explicitly target innovation intermediaries. These instruments are analyzed based on their stated target groups and thematic orientations. Policy instruments are structurally categorized into mix types through cluster analysis based on their target groups and themes, reflecting distinct combinations of intermediary roles and system objectives. Each mix type is treated as a structurally embedded configuration rather than as a set of isolated instruments. The clustering procedure is used heuristically to reveal recurring design logics and should not be interpreted as a classification of ontological types (Fiss, 2011). This method aligns with the comparative logic described by Lijphart (1971), in which structural variation across countries provides the basis for explanatory inference when experimental control is not feasible.

The second phase examines how structurally defined policy-level mix configurations are associated with the innovation performance of the countries in which they are implemented. Performance is measured using the Global Innovation Index (GII), which captures both input-side system capacities and output-side innovation outcomes (Crespo & Crespo, 2016; WIPO, 2024). To enhance interpretive precision, the analysis incorporates robustness checks using disaggregated GII indicators.

This separation in measurement logic reflects a conceptual distinction between the structural conditions of innovation systems and their overall performance outcomes (see Figure 1). In the first phase, selected GII sub-indices are employed to capture specific institutional and infrastructural features that influence the emergence of intermediary-centered policy mixes. These indicators reflect dimensions such as knowledge diffusion, environmental sustainability, and digital infrastructure, which are widely recognized as foundational elements of national innovation systems (Edquist, 2006; B. Lundvall, 2007). In the second phase, the total GII score is used to evaluate whether such structurally configured policy instruments are associated with improved system-level innovation performance in their respective national contexts. Such separation of indicators reflects a mechanism-based logic, wherein distinct phases of institutional causality are represented through proxies aligned with their theoretical function (Flanagan & Uyarra, 2016; Gerring, 2008).

Both phases of analysis are designed as cross-sectional, cross-country comparisons. The goal is not to model dynamic feedback or time-dependent causality, but to uncover how structurally embedded coordination architectures are both conditioned by and consequential

for national innovation capacity. This strategy corresponds to the comparative function of cross-national analysis in policy studies, where countries serve as contextual anchors, while the analysis focuses on structural variation across individual policy instruments as the unit of observation (Howoldt, 2024; Russo & Pavone, 2021). It also aligns with a mechanism-based understanding of policy systems, in which actor roles are institutionally configured and system performance emerges from configuration-level dynamics (Edler & Boon, 2018; Fiss, 2011; Flanagan et al., 2011).



Figure 1. Analytical framework

Notes. This analytical framework reflects a two-phase, cross-national and policy-level analysis of institutional mechanisms.

Source: compiled by the author

Methodology

4.1 Data Sources

The analysis examines how role-centered configurations within national innovation policy mixes are structurally associated with system-level innovation performance. The empirical sample includes 54 countries (2013–2024) for which both STI policy data (OECD STIP Compass) and innovation performance indicators (Global Innovation Index) are available.

The [STIP Compass](#), jointly developed by the OECD and the European Commission, provides a structured database of national STI policy measures categorized by objectives, instruments, governance levels, implementation modes, and target groups (Howoldt, 2024; Russo & Pavone, 2021). The data are collected through standardized policy surveys administered to national governments, who self-report measures in accordance with a common taxonomy defined by the OECD and the EC. As of early 2025, the database includes 1,475 policy measures whose target groups include intermediaries, covering a broad temporal range beginning before 2013. Although Russo and Pavone (2021) highlighted the broad classification of intermediary beneficiaries as a key limitation of earlier versions of the

database, this study addresses that concern by using the updated taxonomy, which includes disaggregated categories of intermediary types. By extracting detailed combinations of intermediary type, policy target, and thematic objective, the analysis constructs role-based configurations of policy architecture not captured in previous typologies.

The analytical window in this study is limited to 2013 to 2024, based on the availability of innovation performance data from the Global Innovation Index (GII), accessed via the World Bank Group's open data platform. While the role-based policy mix configurations are constructed using the full set of 1,475 intermediary-targeted measures, this yields 1,049 intermediary-targeted measures adopted between 2013 and 2024 that can be reliably attributed to individual countries and thus linked to national-level innovation performance indicators. These policy measures span 54 countries and serve as the basis for regression analysis. Since the analysis is conducted at the policy level, all intermediary-targeted measures are retained for structural configuration, including those issued by supranational bodies such as the European Union, although such measures are excluded from the regression sample due to the absence of country-level performance data. Innovation performance is proxied using the GII, which captures both structural and output-oriented dimensions of innovation systems through composite scores and thematic sub-indices (WIPO, 2024).

Several control variables are included to capture structural and institutional features that may influence both the formation of policy configurations and observed innovation performance (Howoldt, 2024). The share of high-technology exports in GDP and the share of manufacturing value added in GDP are used to reflect differences in industrial structure, which have been linked to sectoral innovation intensity and national absorptive capacity in prior studies (K. Smith, 2006). The natural logarithm of population size serves as a proxy for system scale and internal complexity, which affect coordination demands within innovation systems (Nelson & Winter, 1982; Weber & Rohracher, 2012). Policy resource availability is proxied by a numerically coded indicator of national innovation policy budgets, based on classifications introduced by Howoldt (2024). This measure captures differences in the magnitude of public investment in innovation policy, which may shape the scope and coherence of instrument deployment (Edler & Fagerberg, 2017). Institutional context is represented using three binary variables that indicate EU membership, OECD membership, and federal governance. These indicators reflect variation in access to transnational policy networks, exposure to policy learning platforms, and vertical authority structures in policy

design (Borrás, 2015; Howoldt, 2024; Malik & Cunningham, 2006). The inclusion of federalism is particularly important given that the dataset does not systematically capture subnational-level instruments, which could introduce estimation bias in multi-level governance systems (Howoldt, 2024). All institutional variables are coded at the year prior to policy mix configuration in order to reflect pre-existing structural conditions and to preserve temporal ordering in the explanatory framework (Aghion et al., 2009; Flanagan et al., 2011). Appendix A reports the detail of the variable definitions.

4.2 Key Variables

4.2.1 Policy Mix Structure

This study develops an original, role-centered classification of national innovation policy mixes by identifying internally coherent configurations of policy initiatives that embed intermediary functions. Rather than conceptualizing policy mixes as simple instrument portfolios, this approach emphasizes how policies assign roles to intermediaries through combinations of target domains and thematic priorities. The resulting configurations are interpreted as institutional structures that shape coordination mechanisms within innovation systems.

The construction of the mix indicators draws on 1,475 policy measures whose target groups include intermediaries recorded in the [OECD STIP Compass](#). Each measure explicitly targets at least one intermediary actor, such as incubators, technology transfer offices, or academic societies. The coding process decomposes each measure into binary variables representing its intermediary type, target group category, and thematic focus. Specifically, dummy variables were created to identify key categories of intermediary and target actors. For intermediary types, these include incubators and science parks, industry associations, academic societies, technology transfer offices, and nongovernmental organizations. Additional target categories were constructed for government bodies, public and private research organizations, educational personnel, industrial actors (such as firms, entrepreneurs, and investors), and societal groups. Each dummy takes the value of 1 if the target group field of a policy includes the corresponding actor category.

These binary indicators were used to identify recurring patterns of intermediary alignment across thematic and target dimensions. To capture latent structures of co-occurrence, pairwise correlations among all binary variables were computed, and hierarchical clustering was applied to the resulting correlation matrix. Four clusters were selected based

on the dendrogram structure and theoretical interpretability. These clusters represent empirically derived configurations of intermediary involvement. Each policy measure that includes intermediaries as one of its target groups was assigned to a cluster based on structural patterns of co-occurrence between target groups and policy themes. Policies were not exclusively assigned to a single cluster; instead, each policy received a share-based assignment across all four clusters, with values summing to one. These cluster shares are interpreted as indicators of role embedding, not as intensity or frequency measures.

The four configurations are summarized in Table 1. Mix 1 includes incubators and technology transfer offices, targeting industrial systems and themes such as entrepreneurship and co-creation. Mix 2 features industry associations and NGOs with a focus on net-zero transitions and ocean-based innovation. Mix 3 is defined by academic societies engaged in research education and personnel development within the public research system. Mix 4 reflects policy initiatives without intermediary actors, typically addressing government and societal groups under generic governance themes.

Table 1

Structural Composition of the Four Policy Mix Configurations

Policy Mix	Intermediary Roles					
1	System-Integrated Configuration					
	Intermediaries		Other Target		Themes	
	Incubators	Technology Transfer Office	Industrial systems Dummy		Innovation in firms and innovative entrepreneurship	Knowledge exchange and co-creation
2	Issue-specific coordination					
	Intermediaries		Other Target		Themes	
	Industry associations	NGOs			Supporting innovation in ocean economic activities	Net zero transitions
3	Research-centric embedding					
	Intermediaries		Other Target		Themes	
	Academic societies		Research education Dummy	Personnel Dummy	Public research system	Human resources for research and innovation
4	Institutional exclusion					
	Intermediaries		Other Target		Themes	
			Government Dummy	Social groups Dummy	Governance	Research and innovation for society

Notes. Policy mix types were constructed through hierarchical clustering of co-occurring target groups and policy themes in 1,475 STI policy measures. The table summarizes the defining components of each configuration.

Source: compiled by the author

These four configurations correspond to distinct structural roles played by intermediaries in innovation policy design. Mix 1 reflects a system-integrative role, in which intermediaries act as central coordinators bridging fragmented institutional domains (Klerkx & Leeuwis, 2009; Weber & Rohracher, 2012). Mix 2 embodies an issue-specific orchestration role, facilitating targeted responses to emerging technological or environmental challenges (Polzin et al., 2016). Mix 3 represents a research-insulated role, structured around academically oriented initiatives with limited systemic linkage (Martin & Etzkowitz, 2000). Mix 4 indicates institutional exclusion, where intermediary functions are either omitted or structurally unassigned, reflecting gaps in policy coordination capacity (Peters, 2001).

These role structures provide the conceptual basis for examining how innovation system characteristics shape the emergence of different mix types, and how these types are associated with variations in national innovation performance. The empirical strategy that follows is grounded in this typology.

To operationalize this clustering process, a series of binary dummy variables were created to capture intermediary types and target group categories based on the OECD STIP Compass taxonomy. The full coding definitions used for these variables are summarized in Appendix B.

4.2.2 Innovation Performance

This study adopts the Global Innovation Index (GII) as the principal measure of national innovation performance. The GII provides a multidimensional, system-level representation of innovation capacity, encompassing input-side domains such as institutional quality, education, and infrastructure, as well as output-side components such as knowledge production, digital diffusion, and innovation linkages (WIPO, 2024). This design makes it particularly suited to the evaluation of intermediary-based policy mixes, which operate at the level of national innovation systems and are intended to structure coordination mechanisms rather than produce immediate outputs.

Given its composite nature, the GII is not designed for longitudinal comparison within countries. Many of its components are based on multi-year averages or lagged indicators, and methodological changes limit time-series comparability. The index itself advises against year-on-year ranking comparisons and instead encourages its use as a cross-sectional or structural

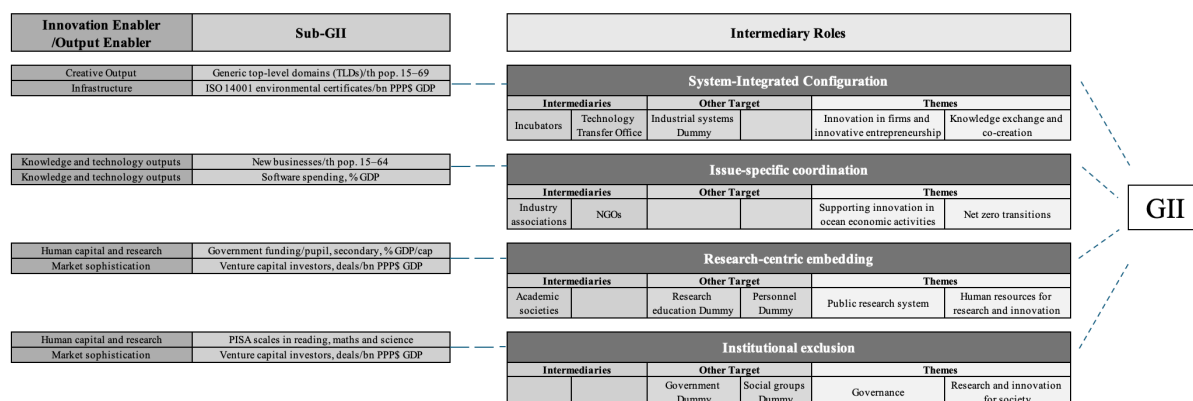
benchmark (WIPO, 2024: Appendix I). Accordingly, this study uses the GII to assess structural system performance across countries, treating each annual value as a contemporaneous indicator of national innovation capacity.

To identify the structural dimensions most relevant to each policy mix configuration, a two-phase variable selection strategy is employed. In the first phase, LASSO regression is applied to estimate the association between the prevalence of each mix type and the full set of available GII sub-indices. LASSO is appropriate in high-dimensional settings where the number of predictors approaches or exceeds the sample size, and it consistently identifies relevant variables under approximate sparsity assumptions (Belloni et al., 2014; Tibshirani, 1996). The top thirty sub-indices are retained for each mix based on non-zero coefficient frequency across cross-validated models. These are subsequently filtered to exclude variables with more than 40% missing observations between 2013 and 2024.

In the second phase, stepwise logistic regression with backward elimination based on the Akaike Information Criterion (AIC) is applied to each mix-specific subset. This yields a refined, parsimonious set of structural indicators that are both statistically stable and thematically interpretable. Table 2 presents the final matched indicators for each mix configuration.

Table 2

GII Sub-Pillars Matched to Policy Mix Types



Notes. Variables selected via LASSO and stepwise AIC represent structural characteristics most predictive of each policy mix configuration. Thematic interpretation draws on intermediary types, target domains, and functional logics.

Source: compiled by the author

The selected indicators correspond to the structural roles embedded in each mix type. For Mix 1, indicators such as domain-level digital infrastructure and environmental certification reflect system components where coordination gaps are likely to emerge despite high overall capacity. These features are consistent with its interpretation as a system-integrated configuration designed to align fragmented institutional actors (Klerkx & Leeuwis, 2009; Weber & Rohracher, 2012). Mix 2 is linked to indicators associated with entrepreneurial intensity and digital absorptive capacity, such as software expenditure and new business formation. These characteristics support the understanding of Mix 2 as an issue-specific orchestration mechanism targeting emerging opportunity spaces (Autio et al., 2014; Polzin et al., 2016). The selection of research-related and education-focused indicators for Mix 3 reflects a configuration centered on academic institutions with limited systemic engagement. This profile aligns with the notion of an inward-facing research logic anchored in Mode 1 knowledge production (Gulbrandsen & Slipersæter, 2007; Martin & Etzkowitz, 2000). Mix 4 is matched to indicators such as educational performance and public governance capacity, which reflect structural conditions under which intermediary roles are not institutionally embedded. This supports its interpretation as a condition of institutional exclusion or policy inaction (Peters, 2001).

These correspondences provide a substantive basis for interpreting the selected indicators as proxies for system-level structural features relevant to intermediary configuration. In the empirical analysis that follows, these variables are used in the first-phase regression models to assess how structural innovation system conditions shape the emergence of different policy mix types. The second-phase models then evaluate how these mix structures relate to overall system performance using the total GII score as the dependent variable.

4.3 Empirical Strategy

This study employs a two-phase, mechanism-oriented empirical strategy, implemented in R (primary) and Stata (complementary), to examine how national innovation systems and policy designs are structurally interlinked. Instead of estimating treatment effects within a country-level panel framework, this study treats individual STI policy measures as observations and focuses on how their structural configurations relate to country-specific institutional conditions and subsequent system-level performance. This two-phase empirical strategy reflects a mechanism-based understanding of causation, which emphasizes

temporally ordered and theoretically grounded linkages between institutional structures and policy outcomes, rather than relying on direct covariation (Fiss, 2011; Gerring, 2008).

The empirical strategy follows a two-phase, cross-sectional comparative design anchored at distinct observational points (t_1 , t_2 , t_3). In the first phase, the analysis investigates whether and how national innovation system conditions at t_1 shape the role configuration of individual STI policy measures observed at t_2 . Each policy is treated as an observation and matched to the GII indicators and structural controls of its country at the relevant year. For instance, GII indicators and control variables from 2012 are matched to policy mix data from 2013. Policy mixes are operationalized as the relative share of intermediary-targeted instruments, classified by actor-level targets and thematic orientations. The bounded nature of these proportion-based dependent variables is addressed using a fractional response framework. Following the approach proposed by Papke and Wooldridge (1996), the estimation applies a fractional logit specification to model outcomes constrained between zero and one. All continuous covariates are normalized to the $[0,1]$ interval using min–max transformation to facilitate interpretability and comparability across model specifications.

The second phase examines whether these structurally defined policy mix types, observed at t_2 , are associated with differences in innovation performance at t_3 . For example, policy instruments implemented in 2013 are linked to performance indicators in 2016, allowing for a three-year interval between mix design and observed outcomes. Rather than evaluating changes within countries over time, this phase compares how policies with different role configurations, implemented across countries at t_2 , are associated with national performance outcomes at t_3 . To account for potential institutional persistence and context effects, the models incorporate control variables from t_2 , which corresponds to the year immediately preceding the performance year. Robustness checks using disaggregated GII components further examine whether different policy mix types align more closely with system conditions related to institutional investment, knowledge production, or entrepreneurial activity (Edler & Boon, 2018; Flanagan et al., 2011).

This two-phase structure reflects a conceptual distinction between structural conditions and system-level outcomes. The first phase employs selected GII sub-indices to represent specific institutional features of national innovation systems, such as knowledge diffusion, regulatory infrastructure, and sustainability frameworks. These dimensions are

theorized to shape the configuration of intermediary roles within policy design (Edquist, 2006; B. Lundvall, 2007). In contrast, the second phase utilizes the total GII score to measure the broader performance of the innovation system. This aggregated outcome variable reflects the overall coherence and capacity of the system, and is therefore appropriate for evaluating the system-level impact of structural policy arrangements. The distinction in measurement aligns with a mechanism-based analytical approach, which holds that different phases of institutional causality should be represented through empirically and conceptually matched indicators (Flanagan & Uyarra, 2016; Gerring, 2008).

Although the empirical design incorporates a temporal sequence, the analysis does not model a deterministic causal chain from t_1 to t_3 . Rather, it treats individual policy measures as structured observations embedded in national contexts, allowing for temporally ordered yet cross-sectional comparison. The first phase focuses on identifying the institutional preconditions associated with policy structure formation, while the second explores how such structures correspond to system-level performance outcomes. This strategy aligns with a mechanism-based tradition in institutional analysis, which seeks to identify embedded relationships between policy architectures and macro-level outcomes through structured comparison (Fiss, 2011; Flanagan et al., 2011; Gerring, 2008).

4.4 Regression Models

The empirical analysis is structured around two regression models corresponding to the two phases of the mechanism-based framework. The unit of analysis is the individual policy measure. Each observation corresponds to a single STI policy recorded in the OECD STIP Compass and is matched to national-level structural indicators for the corresponding country and year. These models allow for sequential estimation of how structural features of innovation systems influence the formation of intermediary-centered policy mixes, and how these policy configurations in turn shape system-level innovation performance.

The first-phase model examines how structural characteristics of national innovation systems are associated with the emergence of specific policy mix configurations.

$$\text{PolicyMix}_{i,t} = \rho_0 + \rho_1 \text{GII}_{i,t-1}^{(1)} + \rho_2 \text{GII}_{i,t-1}^{(2)} + \rho_3 X_{i,t-1} + \rho_4 D_{i,t-1} + \delta_t + \varepsilon_{i,t} \quad (1)$$

Here, The dependent variable $\text{PolicyMix}_{i,t}$ denotes the structural configuration assigned to each policy, based on clustered patterns of target groups and thematic focus (see Section 4.2.1). $\text{GII}_{i,t-1}^{(1)}$ and $\text{GII}_{i,t-1}^{(2)}$ selected through LASSO and stepwise AIC, are included as

proxies for national innovation system conditions such as software expenditure as a percentage of GDP. The vector $X_{i,t-1}$ includes lagged control variables such as the log of population size, manufacturing value added (MVA), high-tech exports, and public innovation policy budgets. The vector $D_{i,t-1}$ captures time-lagged institutional characteristics of each country, including binary indicators for EU and OECD membership as well as federal governance status. These dummies are lagged to preserve temporal ordering and reflect the structural policy environment preceding mix formation. Year fixed effects δ_t account for global trends and common shocks, and $\varepsilon_{i,t}$ is the idiosyncratic error term. Given that the dependent variable is a proportion bounded between zero and one, the model is estimated using a fractional logit specification following Papke and Wooldridge (1996). All continuous covariates are normalized to the $[0,1]$ interval using min–max transformation to facilitate comparability. GII sub-indices, originally scaled from 0 to 100, are also rescaled to $[0,1]$ to ensure consistency with the proportional outcome structure.

The second-phase regression evaluates the relationship between policy mix structures and aggregate innovation outcomes observed three years later:

$$\text{GII}_{i,t+3} = \beta_0 + \beta_1 \text{PolicyMix}_{i,t} + \beta_2 X_{i,t+2} + \rho_4 D_{i,t+2} + \delta_t + \varphi_{i,t} \quad (2)$$

In this model, the dependent variable $\text{GII}_{i,t+3}$ represents the total innovation performance score of the country associated with policy i , measured three years after the policy's implementation year. The GII total score, originally reported on a 0–100 scale, is normalized to the $[0,1]$ interval to ensure consistency with the fractional logit model and comparability across phases. The key explanatory variable, $\text{PolicyMix}_{i,t}$, reflects the embeddedness of a specific intermediary role configuration within the national policy mix, as introduced in Section 4.2.1. The control vector $X_{i,t+2}$ includes the same structural variables introduced in the first-phase model, namely log population, manufacturing value added, high-tech exports, and policy budget. In this second-phase specification, they are measured one year prior to the outcome (at $t+2$) to maintain temporal ordering and reduce simultaneity bias. These controls adjust for persistent structural heterogeneity across national innovation systems. This temporal alignment of controls reflects established practice in comparative innovation studies (Aghion et al., 2009) and addresses concerns about over-specification and multicollinearity in panel regression models (Roodman, 2009). Institutional dummy variables $D_{i,t+2}$ are also included to control for persistent country-level structural characteristics, updated to reflect the institutional context one year prior to performance measurement. Year

fixed effects δ_t account for global shocks and cross-country common trends. The model is estimated using fractional logit regression with robust standard errors to address heteroskedasticity and serial correlation.

Result

5.1 Descriptive Patterns of Intermediary-Based Policy Mixes

To motivate the subsequent heterogeneity analysis, this section first examines the empirical distribution of policy mix types across countries. Countries are grouped into three tiers based on their 2024 Global Innovation Index (GII) rankings: Level 1 includes the top 15 countries, Level 2 ranks 16 to 30, and Level 3 includes those below 30. Figure 2 shows considerable variation in the share of each policy mix across countries. While system-integrated and research-only configurations are generally dominant, some countries deviate strongly. Luxembourg (LUX) shows a disproportionate reliance on system integration, and Slovakia (SVK) concentrates heavily on research-only embedding. Issue-specific coordination is rare and mostly appears in mid-tier systems. Institutional exclusion is more common in low-capacity countries, with Bosnia and Herzegovina (BIH) as an extreme case.

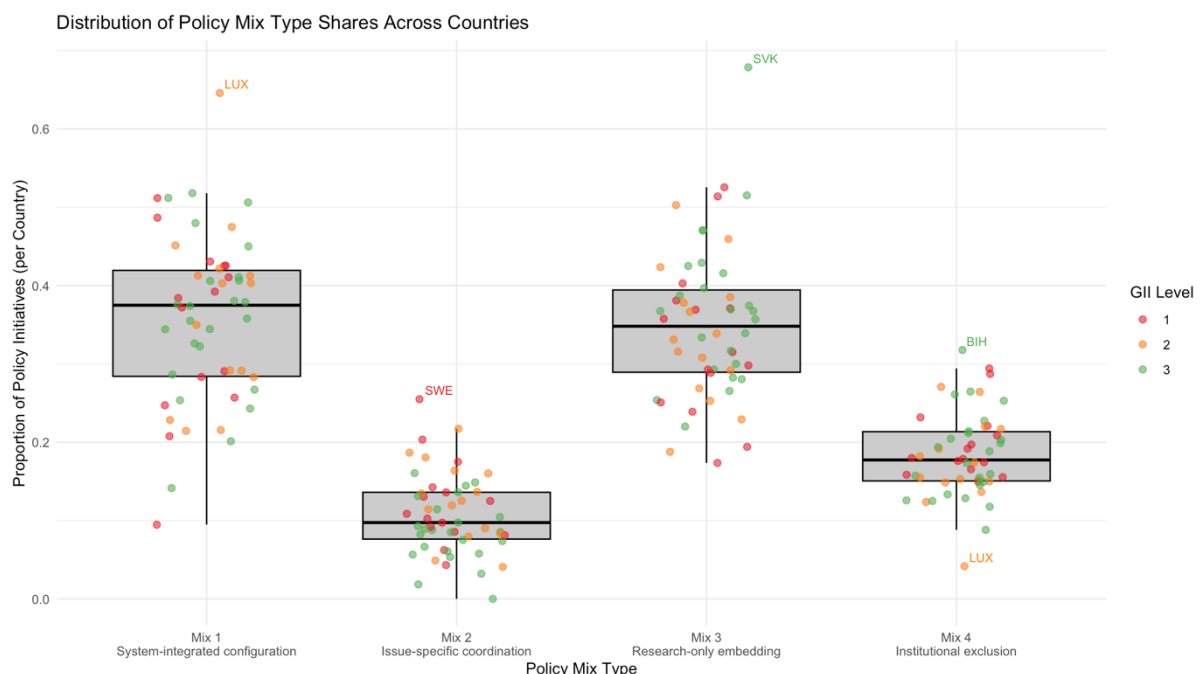


Figure 2. Distribution of Policy Mix Types Shares Across Countries

Notes. Each dot represents a country's share of policy initiatives assigned to a given mix type. Boxplots reveal the cross-country distribution and structural dispersion of intermediary-based configurations.

Source: Author's calculations

Clear patterns emerge in how policy configurations vary across innovation capacity tiers, as shown in Figure 3. System-integrated configurations are most common in top-ranked countries but also appear in the middle tier due to outliers like Luxembourg. Research-only embedding is stable across tiers, though its high average in Level 3 is driven by Slovakia. This pattern reflects persistent research systems without broader integration (Martin & Sunley, 2006). Issue-specific coordination peaks in Level 2, consistent with its flexibility in partially developed systems (Autio et al., 2014). Institutional exclusion is highest in Level 3, often due to missing policy structures rather than deliberate design (Peters, 2001).

These patterns suggest that intermediary configurations do not follow a linear pattern but reflect selective responses to structural and institutional conditions. The next section tests these relationships using regression analysis.

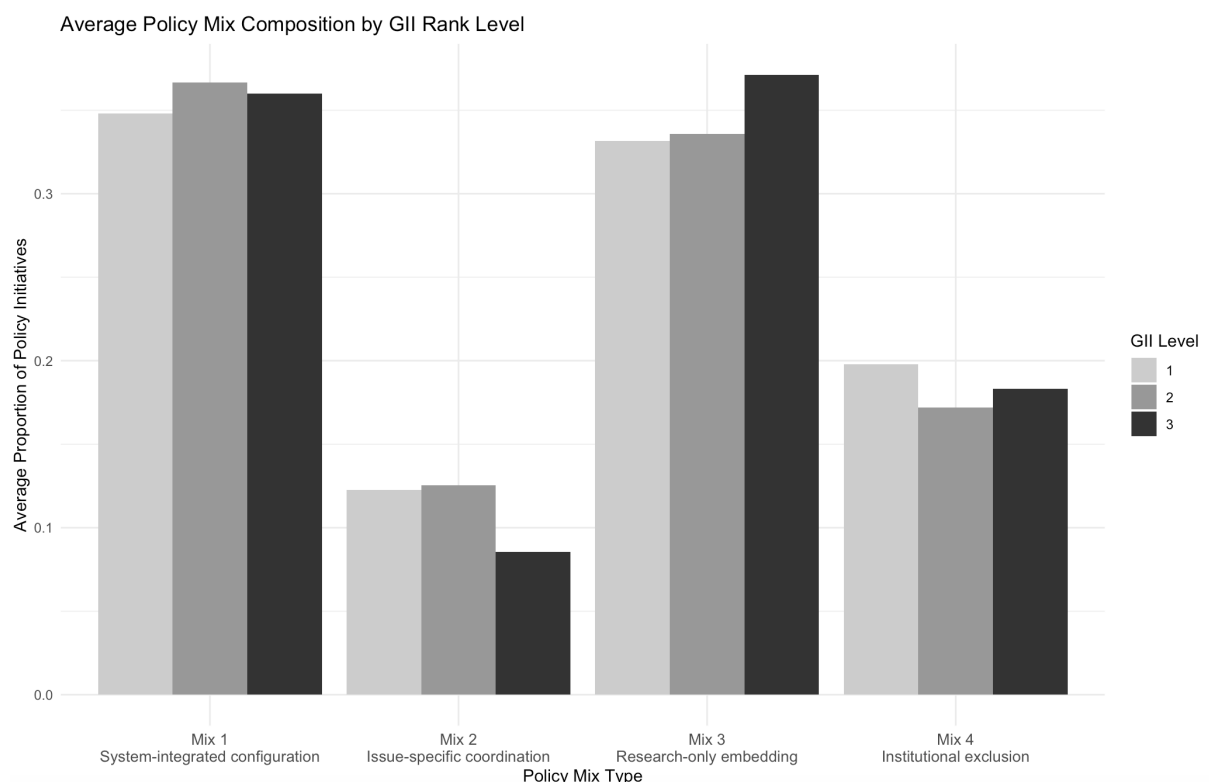


Figure 3. Average Policy Mix Composition by GII Rank Level

Notes. Bars represent the average share of individual policy measures classified under each mix type, aggregated by country groups based on GII rankings.

Source: Author's calculations

5.2 Descriptive Statistics and Variable Correlations

Table 3 and Table 4 presents the descriptive statistics of the variables used in the two-phase regression models relating variation of innovation policy mix foci to innovation capability. All variables are at the policy level. Mix 1–4 represent the structural composition shares of each policy, with values summing to one per observation; a maximum value of 1 indicates fully assigned configurations. Innovation indicators and institutional variables are detailed in Appendix A. GII-based indicators are normalized to [0, 1], and institutional variables are coded as binary dummies. Policy Budget is converted from categorical ranges into numeric values following Howoldt (2024); see Appendix A for coding details. For the dummy variables, the value in the “Mean” column indicates the share of instruments where the dummy takes the value of 1. Table 5 and Table 6 present variable correlations. The highest correlation coefficients are those of software expenditure with new business density (0.52) and with venture capital investment (0.48). To complement the descriptive statistics, Appendix D present the empirical distributions of Mix 1 through Mix 4 at the policy level. These distributions reflect the structural variation of intermediary-based configurations across individual policy instruments, with Mix 2 and Mix 4 exhibiting highly skewed patterns that suggest selective rather than systemic embedding.

Table 3

Descriptive statistics of all variables (First-Phase)

Variables	Mean	SD	Min	Median	Max
Mix 1	0.36	0.24	0.00	0.33	1.00
Mix 2	0.12	0.13	0.00	0.11	0.67
Mix 3	0.34	0.23	0.00	0.33	1.00
Mix 4	0.18	0.16	0.00	0.17	0.75
TLDs/pop.	0.28	0.27	0.00	0.17	1.00
Env_cert/GDP	0.27	0.23	0.01	0.19	1.00
NewBiz/pop.	0.19	0.20	0.00	0.11	1.00
Software/GDP	0.38	0.19	0.01	0.36	1.00
GovFund/pupil	0.32	0.14	0.00	0.32	0.93
VC_deals/GDP	0.20	0.26	0.00	0.10	1.00

PISA_scores	0.60	0.17	0.00	0.64	1.00
High-tech Exports	0.04	0.05	0.00	0.02	0.29
Manufacturing VA	14.90	5.66	4.08	13.40	34.86
Population (log)	16.94	1.47	12.70	17.27	21.07
Policy Budget	0.29	1.01	0.00	0.00	5.00
OECD Member	0.83	0.38	0.00	1.00	1.00
Federalism	0.26	0.44	0.00	0.00	1.00
EU Member	0.59	0.49	0.00	1.00	1.00

Notes. All variables are at the policy level.

Source: compiled by the author

Table 4

Descriptive statistics of all variables (Second-Phase)

Variables	Mean	SD	Min	Median	Max
Mix 1	0.36	0.24	0.00	0.33	1.00
Mix 2	0.12	0.13	0.00	0.11	0.67
Mix 3	0.34	0.23	0.00	0.33	1.00
Mix 4	0.18	0.16	0.00	0.17	0.75
GII	0.45	0.09	0.26	0.44	0.68
TLDs/pop.	0.30	0.30	0.00	0.17	1.00
Env_cert/GDP	0.24	0.21	0.01	0.17	1.00
NewBiz/pop.	0.19	0.20	0.00	0.12	1.00
Software/GDP	0.39	0.21	0.01	0.36	1.00
GovFund/pupil	0.32	0.12	0.00	0.33	0.76
VC_deals/GDP	0.21	0.27	0.00	0.10	1.00
PISA_scores	0.58	0.18	0.00	0.64	1.00
High-tech Exports	0.04	0.06	0.00	0.02	0.34
Manufacturing VA	14.79	5.57	4.31	13.25	37.15
GDP (log)	26.97	1.46	23.10	26.77	30.95
Population (log)	16.98	1.46	12.75	17.33	21.09
Policy Budget	0.29	1.01	0.00	0.00	5.00
OECD Member	0.84	0.36	0.00	1.00	1.00
Federalism	0.26	0.44	0.00	0.00	1.00
EU Member	0.60	0.49	0.00	1.00	1.00

Notes. All variables are at the policy level.

Source: compiled by the author

Table 5

Pearson correlations (First-Phase)

	Mix 1	Mix 2	Mix 3	Mix 4	TLDs/pop.	Env_cert/GDP	NewBiz/pop.	Software/GDP	GovFund/pupil	VC_deals/GDP	PISA_scores	High-tech Exports	Manufacturing VA	Population (log)	Policy Budget	OECD Member	Federalism	EU Member	
Mix 1	1																		
Mix 2	-0.16	1																	
Mix 3	-0.64	-0.37	1																
Mix 4	-0.48	-0.05	-0.15	1															
TLDs/pop.	-0.15	0.15	0.03	0.05	1														
Env_cert/GDP	0	-0.08	0.1	-0.06	-0.14	1													
NewBiz/pop.	-0.06	0.05	0.02	0.01	0.42	0.19	1												
Software/GDP	-0.03	0.13	-0.06	0.01	0.48	-0.19	-0.15	1											
GovFund/pupil	0.05	0.01	-0.05	-0.02	0.18	0.08	0.18	0.16	1										
VC_deals/GDP	-0.07	0.11	-0.02	0.04	0.72	-0.16	0.16	0.51	0.08	1									
PISA_scores	0.04	0.06	-0.02	-0.09	0.41	0.11	0.08	0.36	0.2	0.43	1								
High-tech Exports	-0.07	-0.04	0.13	-0.06	-0.16	0.21	-0.13	-0.19	0.08	-0.13	-0.07	1							
Manufacturing VA	0.03	-0.06	0.05	-0.05	-0.4	0.04	-0.52	-0.12	-0.18	-0.29	0.02	0.59	1						
Population (log)	0.02	0.05	-0.06	0.01	-0.24	-0.4	-0.56	0.15	-0.38	-0.07	-0.06	-0.05	0.32	1					
Policy Budget	0.04	-0.01	-0.02	-0.02	-0.04	0.09	-0.09	0.01	0.07	0.03	0.09	0.02	0.02	0.06	1				
OECD Member	0.05	0.06	-0.08	-0.01	-0.14	-0.19	-0.26	0.27	-0.18	0.08	0.35	0.06	0.21	0.49	0.07	1			
Federalism	-0.16	0.13	0.07	0.05	0.56	-0.4	-0.16	0.28	-0.08	0.42	0.32	-0.09	0.38	-0.05	0.05	0.05	1		
EU Member	0.08	-0.08	0.04	-0.11	-0.08	0.52	0.07	0.04	0.43	-0.15	0.16	0.29	0.01	-0.41	0.08	-0.1	-0.24	1	

Source: compiled by the author

Table 6

Pearson correlations (Second-Phase)

	Mix 1	Mix 2	Mix 3	Mix 4	GII	TLDs/pop.	Env_cert/GDP	NewBiz/pop.	Software/GDP	GovFund/pupil	VC_deals/GDP	PISA_scores	High-tech Exports	Manufacturing VA	GDP (log)	Population (log)	Policy Budget	OECD Member	Federalism	EU Member	
Mix 1	1																				
Mix 2	-0.16	1																			
Mix 3	-0.64	-0.37	1																		
Mix 4	-0.48	-0.05	-0.15	1																	
GII	-0.06	0.15	-0.04	0.02	1																
TLDs/pop.	-0.06	0.12	-0.04	0.06	0.76	1															
Env_cert/GDP	0.01	-0.07	0.1	-0.12	0.05	-0.16	1														
NewBiz/pop.	0.01	0.03	-0.01	-0.02	0.2	0.43	0.14	1													
Software/GDP	0.06	0.09	-0.12	0.02	0.55	0.53	-0.18	-0.1	1												
GovFund/pupil	0.04	0.01	-0.04	0	0.24	0.18	0.19	0.21	0.08	1											
VC_deals/GDP	0.01	0.09	-0.11	0.08	0.66	0.74	-0.18	0.17	0.53	0.06	1										
PISA_scores	0.02	0.13	-0.06	-0.04	0.69	0.47	0.23	0.1	0.4	0.21	0.4	1									
High-tech Exports	-0.1	-0.04	0.14	-0.01	0.08	-0.13	0.23	-0.12	-0.16	0.05	-0.13	-0.06	1								
Manufacturing VA	0	-0.08	0.07	-0.03	0.04	-0.37	0.08	-0.54	-0.09	-0.23	-0.29	0	0.58	1							
GDP (log)	0	0.15	-0.09	0.01	0.42	0.24	-0.37	-0.4	0.48	-0.27	0.34	0.2	-0.1	0.2	1						
Population (log)	0.02	0.04	-0.06	0.02	-0.02	-0.17	-0.41	-0.55	0.23	-0.4	0.01	-0.19	-0.07	0.29	0.85	1					
Policy Budget	0.04	-0.01	-0.02	-0.02	0.05	-0.03	0.01	-0.07	0	-0.01	-0.01	0.05	0	0.02	0.08	0.04	1				
OECD Member	0.04	0.06	-0.07	-0.01	0.15	-0.11	-0.18	-0.26	0.29	-0.25	0.07	0.35	0.08	0.25	0.49	0.47	0.08	1			
Federalism	-0.16	0.15	0.05	0.05	0.48	0.55	-0.42	-0.17	0.32	-0.08	0.41	0.28	-0.08	-0.05	0.59	0.41	-0.04	0.01	1		
EU Member	0.08	-0.1	0.05	-0.12	0.01	-0.09	0.52	0.07	-0.06	0.51	-0.17	0.26	0.36	0	-0.36	-0.4	0.1	-0.11	-0.25	1	

Source: compiled by the author

5.3 Regression Analysis

Tables 7 and 8 present the results from two-phase empirical models. Table 7 shows how structural variables relate to the likelihood of a policy being associated with each type of mix. Each column reports a fractional logit model using a complementary log-log link, with GII indicators scaled to [0, 1] and institutional variables entered as binary controls. Estimates are significant across mixes and reveal distinct patterns of alignment. Table 8 reports the second-phase regressions linking each mix configuration to normalized GII scores. Each model includes one mix share as the explanatory variable and applies a consistent set of control variables. Comments focus on the fully specified models in both phases, while Appendix C provides a visualized summary to facilitate cross-model comparison and enhance interpretability of the findings. Table 9 extends the second-phase analysis by using GII sub-pillar scores as dependent variables to assess the robustness of the main findings.

Table 7

First-phase Regression: fractional response regressions with proportions of four policy mix foci as dependent variables.

Dependent Variable:	Mix 1		Mix 2		Mix 3		Mix 4	
	(1) Baseline	(2) Robustness test	(3) Baseline	(4) Robustness test	(5) Baseline	(6) Robustness test	(7) Baseline	(8) Robustness test
TLDs/pop.	-0.584** (0.221)	-0.483** (0.179)						
Env_cert/GDP	-0.953*** (0.238)	-0.773*** (0.192)						
NewBiz/pop.			1.449*** (0.317)	1.329*** (0.289)				
Software/GDP			1.632*** (0.320)	1.500*** (0.290)				
GovFund/pupil					-0.603* (0.322)	-0.492* (0.265)		
VC_deals/GDP					-0.469** (0.183)	-0.401** (0.152)	0.701*** (0.203)	0.629*** (0.179)
PISA_scores							-1.925*** (0.443)	-1.735*** (0.394)
Population (log)	0.014 (0.045)	0.017 (0.036)	0.151** (0.059)	0.136** (0.053)	-0.075* (0.043)	-0.058* (0.035)	-0.083* (0.047)	-0.075* (0.042)
Policy Budget	0.029 (0.035)	0.019 (0.027)	-0.024 (0.045)	-0.024 (0.042)	-0.020 (0.035)	-0.018 (0.029)	0.034 (0.039)	0.032 (0.035)

Manufacturing VA	-0.004 (0.011)	-0.003 (0.009)	-0.009 (0.013)	-0.008 (0.012)	-0.005 (0.010)	-0.005 (0.008)	0.013 (0.011)	0.012 (0.010)
High-tech Exports	2.672* (1.569)	2.263* (1.246)	0.994 (1.992)	0.838 (1.855)	2.757* (1.433)	2.333** (1.156)	-2.155 (1.659)	-1.997 (1.512)
OECD Member	0.003 (0.127)	-0.011 (0.104)	-0.324* (0.171)	-0.293* (0.157)	0.043 (0.127)	0.030 (0.103)	0.217 (0.151)	0.193 (0.136)
EU Member	0.369*** (0.097)	0.309*** (0.079)	-0.181 (0.115)	-0.166 (0.106)	0.060 (0.094)	0.048 (0.078)	-0.135 (0.104)	-0.119 (0.094)
Federal Member	-0.372** (0.128)	-0.315** (0.105)	0.154 (0.115)	0.146 (0.105)	0.361*** (0.104)	0.291*** (0.085)	0.144 (0.123)	0.133 (0.111)
Constant	-0.295 (0.718)	-0.694 (0.578)	-5.451*** (0.979)	-5.208*** (0.891)	0.850 (0.706)	0.331 (0.576)	0.065 (0.773)	-0.203 (0.693)
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	688	688	656	656	641	641	669	669

Notes. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Logit models are the baseline specification; Cloglog models serve as robustness checks.

Source: compiled by the author

Table 8

Second-phase Regression: Second-phase Regression: fractional response regressions with overall GII as dependent variables.

Dependent Variable:	GII			
	(1)	(2)	(3)	(4)
Mix1	-0.175** (0.054)			
Mix2		0.286*** (0.086)		
Mix3			-0.110** (0.052)	
Mix4				0.183** (0.071)
Population (log)	0.046*** (0.013)	-0.027** (0.012)	-0.027** (0.012)	-0.025** (0.012)
Policy Budget	0.002 (0.013)	0.009 (0.011)	0.008 (0.011)	0.008 (0.011)
High-tech Exports	2.833*** (0.468)	1.680*** (0.406)	1.649*** (0.408)	1.628*** (0.407)
Manufacturing VA	-0.016*** (0.003)	-0.006** (0.003)	-0.007** (0.003)	-0.007** (0.003)
OECD Member	0.101** (0.045)	0.213*** (0.039)	0.217*** (0.039)	0.221*** (0.039)
EU Member	0.142*** (0.032)	0.177*** (0.027)	0.178*** (0.028)	0.185*** (0.028)

Federal Member		0.427***	0.444***	0.438***
		(0.029)	(0.030)	(0.029)
Constant	-0.790***	-0.033	0.041	-0.043
	(0.221)	(0.196)	(0.198)	(0.197)
Year Dummy	Yes	Yes	Yes	Yes
Obs	580	580	580	580

Notes. Standard errors in parentheses. *p < 0.1, ** p < 0.05, *** p < 0.001.

Source: compiled by the author

Table 9

Robustness Check (Using GII Sub-pillars Dependent Variables)

Dependent Variable:	TLDS/POP.	Env_cert/GD P	Software/GD P	NewBiz/pop	VC_deals/G DP	GovFund/pup il	VC_deals/G DP	PISA_scores
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mix1	-0.496** (0.240)	-0.076 (0.171)						
Mix2			0.507* (0.275)	0.497 (0.349)				
Mix3					-1.270*** (0.309)	-0.151 (0.111)		
Mix4							1.016** (0.427)	0.040 (0.126)
Constant	-0.240 (0.901)	-1.236* (0.679)	-3.265*** (0.607)	7.394*** (0.680)	3.155** (1.082)	1.298** (0.403)	2.366** (1.084)	0.875** (0.338)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	416	416	398	413	404	382	404	412

Notes. Standard errors in parentheses. *p<0.1, ** p<0.05, *** p<0.001. This table conducts robustness checks for the second-phase analysis by replacing the overall GII index with selected sub-pillars that reflect distinct innovation capacities.

Source: compiled by the author

5.3.1 Mix 1: System-Integrated Configuration as a Response to Institutional Fragmentation

Mix 1 (System-integrated) reflects a policy configuration in which intermediaries such as incubators and technology transfer offices are structurally embedded to maintain coherence across fragmented innovation systems. These intermediary-rich arrangements are designed to stabilize system coordination in environments where endogenous linkages among innovation actors are weak or discontinuous, reflecting a logic of structural compensation rather than expansion (Klerkx & Leeuwis, 2009).

The first-phase regression results show that Mix 1 is negatively associated with two Global Innovation Index sub-indicators (as shown in Column (1) and (2) in Table 7). The first is the number of generic top-level domains (TLDs) registered per 1,000 people aged 15 to 69, categorized under the Online Creativity sub-pillar of Creative Output (WIPO, 2024). This indicator reflects the extent of participatory digital engagement and decentralized knowledge diffusion, and is measured by counting generic TLDs per 1,000 working-age individuals as a proxy for structural digital accessibility rather than the intensity of digital investment (Leogrande, 2024a; WIPO, 2024). The second is the number of ISO 14001 environmental certificates per billion PPP-adjusted GDP, which falls within the Ecological Sustainability sub-pillar of Infrastructure. This indicator reflects the institutional uptake of voluntary environmental standards and is interpreted as a signal of routinized sustainability governance rather than regulatory enforcement or spending levels (Leogrande, 2024b; WIPO, 2024).

The negative association with the Online Creativity indicator suggests that intermediary-based configurations tend to emerge in systems where participatory digital infrastructures remain underdeveloped. In such contexts, the absence of distributed interfaces for bottom-up innovation may lead policymakers to rely on intermediaries to ensure minimal coordination across disconnected domains. Digital infrastructures serve as institutional gateways for inclusive participation (Castells, 1996), and when these gateways are weak, coordination must be scaffolded through externally embedded roles (Keskin, 2018). Intermediaries thus play a bridging role in environments where trust-based or iterative collaboration cannot be sustained by endogenous institutional routines (Ansell & Gash, 2008).

A similar compensatory logic is observed in the association with ISO 14001 certifications. These certifications represent soft compliance mechanisms and the voluntary uptake of environmental norms (Gunningham et al., 2003). Limited diffusion of such standards indicates that sustainability practices have not yet been institutionalized, creating demand for intermediaries to act as carriers of governance routines. Where collective-choice rules fail to translate into operational structures, coordination is embedded through policy instruments rather than organically produced (Ostrom, 2005). Under such conditions, instruments are more likely to stabilize fragmented systems than to trigger institutional transformation (Scharpf, 1994).

Institutional covariates in the model reinforce this interpretation. Mix 1 is positively associated with EU membership, suggesting that system-integrated configurations are more likely to appear in multi-level governance settings where coordination logics diffuse through established policy platforms (Howoldt, 2024). By contrast, a negative association is found with federal governance structures, implying that decentralized institutional capacity may reduce the necessity of embedding intermediary functions at the national level. These contextual factors characterize background variation and are not interpreted as mechanisms of formation.

In the second-phase regression, as reported in Column (1) in Table 8, Mix 1 is negatively and significantly associated with normalized GII scores measured three years later. Although this lag allows for temporal separation, the relationship is not interpreted as directional. Instead, it suggests that intermediary-dense configurations may stabilize internal coherence without improving outward-facing performance. When institutional interfaces remain weak, internal alignment alone may be insufficient to generate innovation spillovers. Systemic performance depends on the alignment between internal coordination and external structural capacity (Edler & Fagerberg, 2017), and Mix 1 appears structurally constrained to the former.

To assess whether Mix 1 feeds back into the domains from which it emerges, the two first-phase indicators are reintroduced as dependent variables. The findings presenting in Column (1) and (2) in Table 9 show that Mix 1 remains negatively associated with TLDs per capita, while the association with ISO 14001 certification density becomes statistically insignificant. This asymmetry supports the interpretation of structural misalignment. Rather than fostering systemic change, Mix 1 appears to reinforce internal stabilization without

catalyzing diffusion-oriented capacity building. When instruments are embedded in constrained institutional contexts, they tend to reproduce structural limitations rather than overcome them (Flanagan et al., 2011).

National-level characteristics show differentiated associations across structure and performance. High-tech exports and EU membership are positively associated with both the adoption of Mix 1 and subsequent innovation performance, highlighting the role of export-driven capacity and supranational frameworks in supporting system integration (Hausmann & Rodrik, 2002; Veugelers, 2017). In contrast, population size and OECD membership are only significant in the performance phase, suggesting that scale and institutional convergence enhance innovation outcomes but do not directly shape policy architecture (Crescenzi et al., 2007; Edler & Fagerberg, 2017). Manufacturing value-added is negatively associated with performance but unrelated to structural formation, echoing tensions between industrial maturity and knowledge-based coordination (Peneder, 2003). These patterns suggest that institutional conditions enabling coordination design do not always align with those supporting system-wide innovation returns.

5.3.2 Mix 2: Issue-specific coordination as a capability-aligned policy structure

Mix 2 (Issue-specific coordination) reflects a policy configuration in which intermediary structures are selectively embedded to align with thematically bounded innovation domains. Rather than aiming for system-wide integration, this configuration enables targeted coordination in areas where absorptive capacity and stakeholder salience are already present. First-phase regression results indicate that Mix 2 is positively associated with two Global Innovation Index sub-indicators: the number of new businesses per thousand people aged 15 to 64, and software expenditure as a percentage of GDP (as shown in Column (3) and (4) in Table 7). The former captures entrepreneurial responsiveness within the system, while the latter reflects digital absorptive capacity. Both indicators fall within the Knowledge Impact sub-category under the Knowledge and Technology Outputs pillar (WIPO, 2024), and together they suggest that Mix 2 tends to emerge in systems already equipped with partial knowledge circulation and digital readiness (WIPO, 2024). This alignment supports the interpretation that intermediary engagement in Mix 2 is capability-contingent rather than compensatory. In such settings, coordination roles are deployed to enhance flexibility and responsiveness within functional domains, not to repair systemic fragmentation. As Cohen and Levinthal (1990) note, systems with prior absorptive capacity are more likely to activate

selective learning and coordination routines. This logic is consistent with the argument that policy design tends to reflect rather than overcome institutional constraints, adapting to local capacity patterns (Autio et al., 2014; Tödtling & Trippl, 2005).

The composition of Mix 2 reinforces this reading. It involves intermediaries such as industry associations and nongovernmental organizations, whose institutional positioning favors horizontal coordination and sector-specific engagement. These actors frequently operate in contexts such as net-zero transitions or ocean innovation, where policy goals are complex, contested, and not amenable to top-down resolution. Their effectiveness depends not on institutional authority but on the ability to connect actors across functional niches. In settings where soft coordination dominates over formal enforcement, such intermediary forms provide flexible infrastructure for distributed governance (Kivimaa, 2014; Smedlund, 2006). The role of Mix 2, therefore, is not to integrate disjointed domains, but to reinforce coordination within already activated issue spaces. This structural logic contrasts with that of Mix 1, which addresses institutional voids through systemic embedding. By comparison, Mix 2 reflects a design logic that privileges problem-specific adaptability over coherence. Flexible policy architectures have been shown to perform well in such environments, particularly where system responsiveness already exists (Howlett & Rayner, 2013).

Background governance conditions also shape the distribution of Mix 2. Regression results show that this configuration is more frequently observed in federal systems and countries with EU or OECD membership. These associations are not interpreted as causal, but rather as indicative of multi-level governance environments where decentralized coordination is institutionally supported. Intermediaries operating in such systems are more likely to be structurally enabled by horizontal accountability and nested jurisdictions. The compatibility between Mix 2 and these governance types reflects the broader affordances of institutional design, where intermediary engagement functions as a coordination extension rather than a governance substitute. Flanagan et al. (2011) emphasize that the effectiveness of policy mixes depends on their embeddedness in governance architectures that allow for selective alignment.

As for second-phase regression analysis, Column (2) in Table 8 presents that Mix 2 is positively and significantly associated with normalized GII scores measured three years after formation. While this association is not interpreted as causal, it suggests that issue-specific coordination structures may enhance performance in systems where institutional

responsiveness is already present. Rather than triggering transformation, Mix 2 appears to reinforce coordination channels that align with existing absorptive structures. Performance improvements are therefore better understood as the outcome of structural compatibility rather than instrument novelty. Edler and Fagerberg (2017) argue that innovation performance depends on the congruence between internal policy structures and the broader institutional landscape. Mix 2 fits this pattern by strengthening coordination in domains where selective engagement can operate effectively (Magro & Wilson, 2019).

Additional validation comes from reintroducing the original structural indicators as dependent variables. The results in Column (3) and (4) in Table 9 show that Mix 2 remains positively associated with software expenditure, while the association with new business formation becomes statistically insignificant. This asymmetry suggests that Mix 2 reinforces digital absorptive capacity more directly than it stimulates entrepreneurial entry. The configuration appears to build upon infrastructure already in place, enabling knowledge reuse rather than generating new entry points. This supports the interpretation of Mix 2 as a reinforcement mechanism rather than a transformative driver. As Howoldt (2024) observes, capability-aligned configurations tend to stabilize coordination within existing structures, particularly in systems that already exhibit partial maturity.

Moreover, national-level variables show contrasting roles in the formation and performance of Mix 2. Population size is positively associated with the adoption of this configuration, suggesting that larger systems may have the diversity or complexity to support issue-specific coordination (Castellacci & Natera, 2013). However, it is negatively associated with innovation outcomes, possibly reflecting internal coordination burdens in scaled systems (Crescenzi et al., 2007). OECD membership exhibits a negative relationship with Mix 2 formation but a positive association with innovation performance, indicating that structural adoption and policy effectiveness are supported by different institutional logics (Veugelers, 2017). EU and federal membership are unrelated to Mix 2 formation, yet positively linked to innovation outcomes, pointing to the role of supranational and multi-level capacity in boosting performance beyond structural design. These cross-phase differences suggest that capability-aligned coordination structures are shaped by distinct conditions from those that sustain broader system returns (Edler & Fagerberg, 2017).

5.3.3 Mix 3: Research-centric embedding as an internally reinforced policy structure

Mix 3 (Research-centric embedding) reflects a policy configuration in which intermediary roles are structurally anchored within the academic core of the innovation system. This configuration excludes cross-sectoral coordination mechanisms and instead consolidates policy instruments around research education and the development of research personnel. First-phase regression results show that Mix 3 is significantly and negatively associated with two Global Innovation Index sub-indicators: government education expenditure per pupil and venture capital investment, both as a share of GDP (as presented in Column (5) and (6) in Table 7). These two indicators belong to the input side of the Global Innovation Index, specifically under the Education sub-dimension of the Human Capital and Research pillar and the Investment sub-dimension of the Market Sophistication pillar (WIPO, 2024). Their negative coefficients suggest that Mix 3 emerges more frequently in systems where institutional investments, whether public or private, remain underdeveloped. In such contexts, intermediary deployment does not serve to broaden coordination capacity, but rather to reinforce the internal continuity of academic infrastructures. This logic resonates with Flanagan et al. (2011), who argue that instrument choices in resource-constrained environments are often driven by stability goals rather than systemic ambition.

The intermediary composition of Mix 3 supports this interpretation. Unlike Mix 1 and Mix 2, which involve diverse intermediaries with horizontal or bridging capabilities, Mix 3 relies exclusively on academic societies as its coordination mechanism. These intermediaries are structurally embedded within public research organizations and do not facilitate cross-domain interaction. The policy targets are similarly confined, oriented toward internal research development without reference to application-driven goals or stakeholder responsiveness. This inward-facing structure is consistent with Mode 1 knowledge production, in which academic institutions operate autonomously and without systemic engagement (Gulbrandsen & Slipersæter, 2007; Martin & Etzkowitz, 2000). The absence of intermediary diversity limits the capacity of this configuration to stimulate knowledge circulation or respond to external innovation pressures. As Smedlund (2006) notes, structurally enclosed systems often lack the interfaces necessary to connect research production with broader innovation ecosystems.

Governance characteristics reinforce the likelihood of Mix 3 formation. The configuration is significantly more prevalent in federal systems, where institutional autonomy

allows academic actors to consolidate their roles without being embedded in national-level coordination frameworks. By contrast, membership in the European Union or the OECD is not significantly associated with Mix 3, suggesting that transnational policy environments do not directly shape the adoption of inward-oriented structures. This pattern aligns with the view that institutional decentralization can reinforce coordination lock-in, particularly when intermediary functions remain confined to one subsystem (Scharpf, 1994; Weber & Rohracher, 2012).

Second-phase regression results show a significant negative association between Mix 3 and normalized GII scores measured three years after policy adoption (as reported in Column (3) in Table 8). This result is not interpreted as causal, but as a structural reflection of weak systemic connectivity. In systems where intermediary roles remain limited to public science, the absence of feedback channels to industry or society reduces the configuration's ability to support distributed innovation. Edler and Fagerberg (2017) emphasize that performance effects rely on the alignment between internal policy coherence and external institutional openness. Mix 3 demonstrates strong internal continuity but lacks the positional leverage to amplify innovation outcomes beyond the academic core.

To assess whether Mix 3 reinforces the structural conditions from which it originates, the two first-phase indicators are reintroduced as dependent variables. Regression results show a continued negative association with venture capital investment, while the association with education expenditure becomes statistically insignificant (as reported in Column (5) and (6) in Table 9). This asymmetry suggests that Mix 3 does not facilitate the emergence of complementary inputs, particularly from the private sector. The persistence of this pattern is consistent with Howlett and Rayner (2013), who describe instrument layering in structurally enclosed systems as a mechanism of institutional reproduction. Rather than activating new capacities, Mix 3 reflects a coordination logic that stabilizes existing academic trajectories in the absence of broader system integration.

Additionally, Mix 3 reflects a uneven institutional embedding, where certain governance traits coincide with structural adoption, while others shape only performance. Federal membership and high-tech exports are both positively associated with Mix 3 presence and innovation outcomes, suggesting that decentralized systems and export-oriented capacities may provide scaffolding for intermediary engagement even in fragmented policy spaces (Hausmann & Rodrik, 2002). In contrast, population size shows a negative correlation

across both phases, implying that in more populous contexts, structural misalignment and coordination burdens may jointly suppress effectiveness (Crescenzi et al., 2007). Notably, EU and OECD membership are not associated with the adoption of Mix 3, but significantly linked to improved performance. This divergence points to institutional thickness that enhances systemic output without influencing the structure of coordination itself (Edler & Fagerberg, 2017; Veugelers, 2017). Mix 3 thus illustrates a hybrid configuration that structurally enabled by federal or sectoral capacities, while dependent on broader institutional infrastructures to yield performance returns.

5.3.4 Mix 4: Institutional exclusion and centralized emergence without intermediaries

Mix 4 (Institutional exclusion) reflects a policy configuration in which intermediary roles and institutional targeting are structurally absent. Policy instruments are nominally directed toward “research and innovation for society,” but no identifiable actor linkages or coordination frameworks accompany this theme. The only entities referenced are general government bodies and broad social collectives, with no sectoral anchoring or organizational embodiment. This absence of structural integration suggests a governance pattern closer to symbolic agenda-setting, where policy rhetoric is decoupled from viable implementation mechanisms (Kingdon, 1984). Such designs resemble non-decision-making outcomes, which result not from intentional minimalism but from institutional limits in coordination capacity (Howlett & Ramesh, 1995).

Regression results from the first-phase model presented in Column (7) and (8) in Table 7 support this interpretation. The likelihood of Mix 4 adoption is significantly and positively associated with venture capital activity and negatively associated with PISA-based educational performance. These indicators represent distinct input-side dimensions of the Global Innovation Index. Venture capital investment is classified under the Investment sub-dimension of the Market Sophistication pillar and reflects private-sector risk tolerance rather than public coordination (Leogrande, 2024d; WIPO, 2024). PISA scores fall within the Education sub-category under the Human Capital and Research pillar and are interpreted as output-based measures of foundational learning quality (Leogrande, 2024c). The positive association with venture capital suggests that in some systems, entrepreneurial innovation can bypass public coordination entirely, operating through decentralized networks (Altenburg et al., 2008). In contrast, the negative association with education quality implies that institutional exclusion tends to arise in environments where human capital systems are weak,

consistent with evidence that governance gaps correlate with minimalist policy responses (OECD, 2011; Peters, 2001). In some low-capacity systems, innovation responses may emerge through informal, adaptive channels rather than structured institutional design, a logic described by Sabel and Zeitlin (2012) as distributed experimental governance.

The internal structure of Mix 4 reinforces this reading. Unlike the other configurations, it excludes intermediaries such as incubators, NGOs, academic societies, or industry associations. This absence leaves no actors to mediate between levels of governance or domains of innovation. As Jessop (1998) notes, the absence of both vertical control and horizontal coordination characterizes governance failure. Without intermediary interfaces, there is little opportunity for feedback loops or cross-sectoral learning. Howells (2006) stresses that intermediaries play a pivotal role in enabling distributed knowledge flows, and their absence reduces system-wide absorptive capacity. Lundvall (2016) and Morgan (2004) further argue that when knowledge infrastructures are not embedded in national or regional institutions, innovation activity becomes fragmented and non-cumulative.

While the second-phase regression shows that Mix 4 is positively associated with normalized GII scores three years after implementation, this relationship does not suggest policy effectiveness (as shown in Column (4) in Table 8). In structurally thin systems, performance may arise not through intermediary mechanisms but through substitution effects, such as market-based or mission-driven innovation. Kuhlmann and Rip (2018) argue that hierarchical or centralized models may function in the absence of structured coordination. This is particularly true when coordination logics are absorbed within dominant administrative bodies rather than distributed across networks. Weber and Rohrer (2012) observe that innovation can occur in loosely coordinated systems if system pressure is low, while Edler and Fagerberg (2017) caution that structural alignment, not institutional form, determines long-run innovation capacity.

To assess whether Mix 4 reinforces the structural conditions from which it arises, the two first-phase indicators are reintroduced as dependent variables. The configuration remains positively associated with venture capital investment, while its relationship with PISA scores becomes positive but statistically insignificant (as shown in Column (7) and (8) in Table 9). This asymmetry suggests that while decentralized innovation dynamics may be sustained, foundational educational capacities remain unaddressed. As Howlett and Rayner (2013) argue, in thinly institutionalized systems, instrument layering often reproduces existing

structures rather than initiating transformation. When intermediary functions are absent, governance mechanisms may replicate structural voids rather than reconfigure them (Mahoney & Thelen, 2010; Scharpf, 2018). Howoldt, (2024) and Howells (2024) further note that such arrangements may rely on implicit institutional dynamics, but their long-term viability depends on whether broader system scaffolding evolves in tandem with innovation demands.

Mix 4 stands out for its limited structural anchoring but broad institutional correlation with innovation performance. None of the core institutional variables are significantly associated with its adoption, suggesting that this configuration arises independently of formal governance design. However, all three exhibit strong positive links to innovation outcomes, indicating that their influence may manifest through support for system-wide absorptive or investment capacity (Edler & Fagerberg, 2017; Veugelers, 2017). The pattern is echoed in the role of high-tech exports, which show no significant relationship with structure but are robustly associated with performance, pointing to latent technological capabilities that do not necessarily shape intermediary embedding (Hausmann & Rodrik, 2002). Population size is negatively associated with both structure and outcome, potentially reflecting institutional overload or diminishing returns to coordination in large systems (Crescenzi et al., 2007). Hence, Mix 4 illustrates how structurally minimal configurations may nonetheless align with institutional environments that facilitate performance, reinforcing the distinction between policy architecture and systemic capacity.

5.4 Summary and Comparative Insights

The preceding analyses identify four structurally embedded configurations within national innovation policy mixes, each characterized by distinct coordination logics and institutional positioning. These configurations do not merely reflect differences in policy type, but represent coordinated responses shaped by system-level constraints and the roles assigned to intermediaries (Flanagan et al., 2011; Howells, 2006a; Kuhlmann & Rip, 2018).

Mix 1 constitutes a system-integrated configuration, in which formal intermediaries such as incubators and technology transfer offices are deployed to compensate for fragmented infrastructures. This substitutive logic arises in systems marked by weak Creative Output and Infrastructure, and reflects efforts to bridge institutional voids through structural embedding (Kivimaa, 2014; Klerkx & Leeuwis, 2009). However, its negative association with innovation

performance suggests that internal stabilization alone may not foster broader system responsiveness (Edler & Fagerberg, 2017; Magro & Wilson, 2019).

Mix 2 represents a capability-aligned structure featuring soft intermediaries such as NGOs and industry associations. Selectively embedded in issue-specific domains with Knowledge and Technology Outputs, this alignment with output enablers supports flexible coordination aligned with local responsiveness (Smedlund, 2006; Van Lente et al., 2003). Its positive association with innovation performance indicates that targeted structures can reinforce existing knowledge infrastructures rather than substitute for them (Cohen & Levinthal, 1990; Tödtling & Trippel, 2005).

Mix 3 is an inward-oriented configuration anchored in academic societies and public research institutions. It tends to emerge under input-side constraints, including weak Human Capital and Market Sophistication enablers (Gulbrandsen & Slipersæter, 2007; Martin & Etzkowitz, 2000). The configuration's negative performance association reflects internal lock-in under constrained input conditions, where internal continuity fails to generate outward-facing capacity (Howells, 2006a; Janssen et al., 2020; Weber & Rohracher, 2012).

Mix 4 reflects a coordination-absent design, lacking intermediaries or defined targeting. It arises in systems with strong venture capital dynamics but weak educational foundations, consistent with models of institutional thinness and symbolic policy framing (Kingdon, 1984; Altenburg et al., 2008). Although some performance gains are observed, these likely reflect substitution effects rather than structured coordination (Kuhlmann & Rip, 2018; Peters, 2001).

Therefore, these configurations illustrate how structural design mediates the alignment between policy instruments and systemic capacities. Second-phase findings reveal that performance outcomes vary by how well coordination structures align with system-specific enabler conditions (Edler & Boon, 2018; Mahoney & Thelen, 2010). While Mix 2 benefits from selective reinforcement of functional domains, Mix 1 and Mix 3 face limitations when intermediary logic is misaligned with digital, ecological, or human capital enablers. These results highlight the need to understand policy mixes as institutionally embedded coordination architectures. Their structural design is shaped both by intermediary logic and by the system-level enabler dimensions reflected in the GII framework, aligning with broader insights on institutional embedding and policy coordination (Fiss, 2011; Howlett & Rayner, 2013).

Heterogeneity Analysis

The relationship between intermediary-based policy mixes and innovation performance varies across national contexts. Since policy configurations are institutionally embedded, both their formation and their performance effects are shaped by governance regimes and the structural capacities of innovation systems (Fiss, 2011; Flanagan et al., 2011). This section investigates these contingencies through a two-part heterogeneity analysis.

Section 6.1 examines structural heterogeneity in mix formation by comparing countries with different levels of innovation capacity. Using stratified regressions based on the first-phase model, Tables 10 and 11 present how the emergence of Mix 1 and Mix 2 configurations varies across three innovation tiers, defined by countries' 2024 Global Innovation Index (GII) rankings.

Section 6.2 shifts focus to performance heterogeneity and explores how institutional regimes condition the effects of different mix configurations. Table 12 extends the second-phase regression by introducing interaction terms between each mix and governance regime indicators (OECD and EU membership). These tests assess whether the alignment between coordination structures and innovation outcomes is contingent on institutional scaffolding.

These analyses aim to clarify the structural and institutional boundaries under which intermediary-based coordination architectures are more likely to complement or constrain system-level innovation capacity.

6.1 Formation Across Innovation Capacity Levels

To assess whether the structural drivers of intermediary-based policy configurations vary across innovation system contexts, this section conducts a heterogeneity analysis using country-level innovation capacity as a grouping criterion. While country-level GII rankings are used to stratify the sample, the analysis remains at the policy level, focusing on how structural configurations emerge under different systemic conditions. Countries are stratified into three tiers based on their 2024 Global Innovation Index (GII) rankings: Level 1 includes the top fifteen countries, Level 2 includes countries ranked 16 to 30, and Level 3 includes countries ranked below 30. This stratification serves as a proxy for system maturity, reflecting differences in institutional coordination, absorptive capacity, and policy responsiveness (Nelson and Winter, 1982). Separate fractional logit models are estimated within each group to identify how structural conditions such as digital infrastructure, environmental

certification, new business formation, software investment, and public education expenditure differentially shape the emergence of Mix 1 to Mix 4.

The estimation results are reported in Table 10 and Table 11. The system-integrated configuration (Mix 1) shows significant negative associations with both top-level domains per capita and ISO 14001 certifications relative to GDP, particularly within Level 1 countries. This suggests that this configuration emerges primarily in high-capacity systems. In such settings, specific coordination failures become more visible against an otherwise robust institutional backdrop. This supports the interpretation of Mix 1 as a compensatory policy structure that responds to fragmented digital or sustainability infrastructures within complex innovation systems (Pierson, 2000; Weber & Rohracher, 2012). The fact that these associations are not observed in Level 2 or Level 3 countries indicates that in less mature systems, the functional rationale for Mix 1 may be either less relevant or structurally infeasible.

The issue-specific coordination configuration (Mix 2) exhibits a different pattern. Its emergence is significantly associated with new business density and software expenditure in Level 2 and Level 3 countries, but not in Level 1. This suggests that Mix 2 functions as a reinforcement-oriented configuration, aligned with the presence of entrepreneurial and digital absorptive capacity rather than with institutional repair. This interpretation is consistent with Autio et al. (2014), who emphasize the importance of contextual embeddedness in shaping the responsiveness of innovation policy. In systems with moderate but growing innovation capacity, Mix 2 may provide a flexible mechanism for coordinating decentralized actors around emerging economic or technological opportunities.

The research-centric configuration (Mix 3) presents generally negative associations concentrated in Level 1 and Level 2 countries. Specifically, the configuration is negatively associated with both government education expenditure per pupil and venture capital investment, reinforcing its interpretation as an inward-facing structure dominated by public research organizations. These findings resonate with the characterization of Mode 1 knowledge production, in which universities operate as autonomous institutions with limited system-wide engagement (Martin & Etzkowitz, 2000). In such configurations, policy interventions may reinforce academic silos rather than integrate research into broader innovation ecosystems. This interpretation aligns with observations from (Gulbrandsen &

Slipersæter, 2007), who document the limited permeability of academic organizations in structurally inward systems.

The institutional exclusion configuration (Mix 4) displays a more ambiguous pattern. While it shows a significant positive association with venture capital activity in Level 1 countries, its association with educational performance is negative in Level 2 and Level 3 systems. This configuration, which lacks intermediary engagement and clear sectoral targeting, may reflect institutional exclusion or non-decision processes in innovation governance. In low-capacity systems, the emergence of Mix 4 may not represent a deliberate choice but rather a structural omission resulting from limited administrative capability or strategic intent (Peters, 2001). At the same time, the positive association with venture capital may reflect the presence of alternative, market-driven innovation trajectories that develop independently of public coordination. This aligns with Howlett and Rayner (2013), who argue that in some settings, innovation policy may evolve through narrow layering and implicit design structures rather than formal strategic planning.

Therefore, these findings highlight the contextual sensitivity of intermediary-based policy configurations. Rather than being universally applicable, their emergence depends on how well their functional logic aligns with system-level constraints and capacities. This reinforces a configurational understanding of policy design, where structural coordination challenges are mediated through embedded institutional mechanisms rather than addressed through instrument replication or direct emulation (Flanagan et al., 2011; Pierson, 2000).

Table 10

Heterogeneous Test: Heterogeneous Formation Mechanisms by Innovation Tier (Mix 1 & 2)

Dependent Variable:	Mix1			Mix 2		
	(1) Level 1	(2) Level 2	(3) Level 3	(4) Level 1	(5) Level 2	(6) Level 3
TLDS/POP.	-1.196** (0.577)	-0.525 (0.346)	-0.101 (1.594)			
ENV_CERT/GDP	-1.510* (0.771)	-0.063 (0.269)	-0.388 (0.403)			
NewBiz/pop.				1.107 (0.710)	1.328** (0.597)	1.267* (0.750)
Software/GDP				1.135 (0.948)	2.131** (0.650)	0.698 (0.558)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Obs	179	292	345	177	278	326

Notes. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Source: compiled by the author

Table 11

Heterogeneous Test, continued: Heterogeneous Formation Mechanisms by Innovation Tier (Mix 3 & 4)

Dependent Variable:	Mix 3			Mix 4		
	(7) Level 1	(8) Level 2	(9) Level 3	(10) Level 1	(11) Level 2	(12) Level 3
PISA_scores				-1.990 (1.553)	-2.231** (0.889)	-1.538*** (0.462)
GovFund/pupil	-1.387 (1.113)	-1.515** (0.630)	-0.726 (0.509)			
VC_deals/GDP	-1.250** (0.464)	-0.933** (0.473)	-0.303 (0.934)	0.389 (0.516)	0.062 (0.520)	1.411 (1.077)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Obs	176	280	303	179	283	303

Notes. Standard errors in parentheses. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.001$.

Source: compiled by the author

6.2 Performance Effects Under Institutional Regimes

To examine how the performance effects of intermediary-based configurations are conditioned by institutional environments, this section conducts a heterogeneity analysis using interaction terms between policy mix types and institutional regime indicators. Although the main regression models included three institutional dummies representing EU membership, OECD membership, and federal governance, only the first two are incorporated into the interaction specification. The federal governance variable is excluded due to the substantial heterogeneity observed in its association with Mix 1, where countries classified as federal exhibited divergent patterns in intermediary deployment. Including this dimension in the interaction terms would compromise the interpretability of the moderating effects. In contrast, EU and OECD membership represent more stable and comparable institutional regimes, and are frequently used in cross-national analyses of innovation policy. To further address potential income-related institutional variation, GDP per capita is included as an additional control variable. This adjustment enhances the precision of the interaction estimates and follows established practices in institutional analysis (Angrist & Pischke, 2008; Rodrik et al., 2002).

Table 12 presents the results. The analysis centers on the interaction coefficients rather than the main effects, in order to isolate institutional moderation. The results show that the effect of the system-integrated configuration (Mix 1) is positively moderated by OECD membership. In OECD countries, where formal coordination routines and institutional platforms are well established, Mix 1 structures may operate more effectively by leveraging existing integration mechanisms. This pattern supports the view that system-integrated designs depend on strong institutional scaffolding to function as intended (Edler & Fagerberg, 2017). On that note, they can be interpreted as structurally compensatory mechanisms responding to coordination gaps by embedding intermediary roles within mature systems. In contrast, the interaction between Mix 1 and EU membership is significantly negative, suggesting that regional membership alone may constrain the effectiveness of system-integrated structures in the absence of national-level institutional maturity. While OECD and EU are both treated here as institutional proxies, their organizational logics differ: OECD operates more as a platform for policy benchmarking and coordination, while EU membership entails regulatory alignment and supranational governance. These differences may partially explain the divergent interaction results.

For the issue-specific coordination configuration (Mix 2), significant positive interactions are observed with OECD membership, while a weaker positive interaction is also detected with EU membership. This implies that Mix 2 performs better in countries with more developed institutional environments, where its flexible and thematic orientation may complement formal coordination structures rather than substitute for them. This finding departs from earlier assumptions about its adaptive function in looser governance settings and instead aligns with the view that targeted coordination mechanisms can scale more effectively when embedded in broader institutional frameworks (Howlett & Rayner, 2013; Smedlund, 2006).

The research-centric configuration (Mix 3) displays no significant interaction with OECD membership, and only weakly positive effects with EU membership. This suggests that its generally weak association with innovation performance is not substantially moderated by institutional context, but may instead reflect inherent structural limitations. As noted in previous sections, Mix 3 is narrowly embedded within academic infrastructures, and its limited systemic connectivity may constrain its relevance across different regimes (Martin & Etzkowitz, 2000).

The institutional exclusion configuration (Mix 4) shows a significant negative interaction with OECD membership, suggesting that in advanced institutional systems, the absence of intermediary roles may be particularly detrimental. Rather than being offset by alternative governance mechanisms, the lack of structured coordination appears to undermine innovation performance, possibly due to higher system complexity and reliance on formal coordination routines. This result highlights that institutional maturity alone cannot compensate for structural deficiencies in intermediary design. However, the interaction with EU membership is not significant, further reinforcing the view that national-level administrative capacity, rather than regional affiliation, plays a critical role in determining whether non-integrated configurations can function effectively (Peters, 2001; Weber & Rohracher, 2012).

Overall, these findings highlight the contingent nature of policy mix effectiveness. The impact of intermediary-based configurations on innovation outcomes varies with the institutional context in which they are embedded, depending on the alignment between structural design and coordination capacity. Recognizing this complementarity between

structure and context is essential for designing policy mixes that are both theoretically grounded and empirically effective.

Table 12

Heterogeneous Test: Performance Effects Under Institutional Regimes

Dependent Variable:	GII							
	(1) Mix1 × OECD	(2) Mix1 × EU	(3) Mix2 × OECD	(4) Mix2 × EU	(5) Mix3 × OECD	(6) Mix3 × EU	(7) Mix4 × OECD	(8) Mix4 × EU
Mix 1	-0.186** (0.084)	0.040 (0.044)						
Mix 2			-0.283** (0.144)	-0.095 (0.075)				
Mix 3					0.057 (0.079)	-0.062 (0.047)		
Mix 4							0.362*** (0.107)	0.093 (0.060)
Mix 1 × OECD	0.146* (0.088)							
Mix 2 × OECD			0.321** (0.151)					
Mix 3 × OECD					-0.063 (0.083)			
Mix 4 × OECD							-0.275** (0.114)	
Mix 1 × EU		-0.131** (0.053)						

Mix 2 × EU				0.159*					
				(0.092)					
Mix 3 × EU							0.095*		
							(0.057)		
Mix 4 × EU									0.047
									(0.078)
OECD Member	-0.139***		-0.123***		-0.065*		-0.036		
	(0.038)		(0.027)		(0.037)		(0.029)		
EU Member		0.077**		0.008		-0.001			0.028
		(0.024)		(0.020)		(0.024)			(0.021)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Dummy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Obs	708	708	708	708	708	708	708	708	708

Notes. Standard errors in parentheses. * p < 0.1, ** p < 0.05, *** p < 0.001.

Source: compiled by the author

Discussion

This study investigates how intermediary roles are structurally embedded within national innovation policy mixes and how such configurations relate to system-level innovation performance. Rather than viewing policy mixes as additive collections of instruments, it conceptualizes them as institutional arrangements that allocate coordination functions and assign actor roles. This perspective builds on the proposition that policy design embeds assumptions about agency, responsibility, and interaction, thereby shaping the systemic capacities of innovation governance (Edler & Boon, 2018; Flanagan et al., 2011; Rogge & Reichardt, 2016). By focusing on structurally configured roles, the analysis reframes intermediaries not as actor types but as embedded coordination logics within national governance architectures. This role-based perspective explicitly departs from functionalist interpretations, emphasizing structural positioning over intermediary utility. Finally, as a comparative and cross-sectional study, the analysis does not aim to establish causal effects, but to examine how different configurations correspond to varying institutional conditions and performance associations.

The typology developed here identifies four distinct role configurations, each reflecting a different structural logic of coordination. The issue-specific configuration, featuring selective and thematically bounded intermediary roles, is positively associated with absorptive capacity and innovation outcomes. These results align with prior work emphasizing the role of soft intermediaries such as NGOs or industry associations in enabling adaptive coordination in dynamic systems (Autio et al., 2014; Kivimaa, 2014; Smedlund, 2006). By contrast, the system-integrated configuration emerges primarily in environments with fragmented coordination infrastructures. Its association with performance varies across institutional settings: positive in OECD countries but negative in EU contexts. This pattern is consistent with the view that structural alignment alone cannot substitute for institutional capability (Edler & Fagerberg, 2017; Klerkx & Leeuwis, 2009). The research-centric configuration reveals the limits of inward-facing role design: by privileging academic roles without systemic integration, it correlates with lower private-sector involvement and stagnant innovation outcomes, echoing concerns about Mode 1 knowledge production (Gulbrandsen & Slipersæter, 2007; Martin & Etzkowitz, 2000). Its structural confinement explains its low interaction with regime variation, though weak positive effects are observed in EU contexts. The institutional exclusion configuration, though structurally minimal, is negatively

moderated by OECD membership, suggesting that missing coordination structures may be particularly detrimental in mature systems (Peters, 2001; Weber & Rohracher, 2012).

Beyond institutional conditions, the internal alignment of each configuration with input and output structures further clarifies its performance variance. Mix 1 spans both input- and output-side indicators, including environmental certification and digital domain intensity, and thus operates as a dual-fragmentation structure. Its effectiveness depends on multi-dimensional institutional scaffolding that supports coordination across subsystemal divides (Edler & Fagerberg, 2017; Fagerberg et al., 2012). Mix 2 is anchored in output-side absorptive indicators such as software expenditure and entrepreneurial formation. Its stronger performance in institutionalized settings such as OECD and EU countries reflects an output-enhancing role that aligns with structured coordination environments (Autio et al., 2014; Cohen & Levinthal, 1990). Mix 3 is input-constrained, relying exclusively on indicators such as public education spending and lacking intermediary diversity. Its structural confinement explains its low interaction with regime variation, although minor positive effects appear in EU contexts (David, 1994; Gulbrandsen & Slipersæter, 2007). Mix 4 represents an asymmetric input profile, where market-based instruments compensate for weak educational foundations. However, its interaction with OECD membership is significantly negative, indicating that institutional maturity does not offset the absence of embedded coordination, and that governance structures lacking intermediary roles may be more vulnerable to institutional inertia or fragmented change (Mahoney & Thelen, 2010; Rodrik, 2004). These distinctions demonstrate that performance effects emerge not only from intermediary logic but from the way structural roles align with national innovation system dimensions.

These findings underscore the importance of institutional context in shaping both the emergence and effectiveness of coordination structures. The two-phase empirical strategy, based on cross-national comparison rather than time-series modeling, reveals that the formation of role-centered mixes is conditioned by differences in system capacity, while their effects on innovation performance vary with broader governance settings. For instance, the system-integrated mix is more prevalent in high-capacity systems where targeted coordination gaps remain, yet its effectiveness is contingent on institutional scaffolding. Conversely, issue-specific mixes perform better in more structured systems with coordinated absorptive capacity. This confirms that structurally similar configurations may operate differently across contexts, and that governance arrangements shape the operational range of intermediary roles (Howlett & Rayner, 2013; Mahoney & Thelen, 2010).

In practical terms, these results highlight the need to treat intermediary configurations as instruments of strategic design rather than residual elements of implementation. The policy relevance of intermediary roles lies not in their nominal presence but in their structural fit with system conditions. For countries with limited formal coordination platforms, soft intermediary structures may serve as viable substitutes to enable cross-domain alignment. In contrast, high-capacity systems may require more integrative mixes to bridge fragmented subdomains. These implications support recent calls for structure-based policy analysis and provide a mechanism-oriented approach to evaluating the fit between role architecture and systemic need (Fiss, 2011; Flanagan & Uyarra, 2016). Intermediary governance thus emerges not only as a functional necessity, but as a test of institutional design coherence. Its effectiveness can be meaningfully assessed through structure-based comparative approaches.

Conclusion and Future Research

This study investigated how innovation intermediaries are structurally configured within national innovation policy mixes and how these configurations relate to system-level innovation performance. Drawing on 1,049 intermediary-targeted measures from the OECD STIP Compass and matched Global Innovation Index data across 54 countries, the analysis identified four recurrent coordination structures that differ in their role distribution, institutional visibility, and system alignment. These findings suggest that the design of intermediary roles is not incidental but embedded within broader policy architectures, and that the effectiveness of such roles varies with national governance conditions and institutional capabilities.

The study contributes to innovation policy research by shifting attention from instrument combinations to structural role design. It builds on the proposition that policy mixes encode expectations about agency and coordination, and extends this logic to the treatment of intermediaries as analytically distinct and structurally positioned components of governance systems. This perspective reinforces the argument that innovation performance reflects not only policy intensity or thematic focus but also the coherence and adaptability of institutional role configurations. It complements existing frameworks by introducing a mid-level analytical approach that links policy structure with system function through the lens of role construction. Hence, the study extends recent efforts to characterize policy mixes beyond functional or thematic classifications (e.g., Russo & Pavone, 2021) and contributes to a

growing body of work emphasizing the structural coordination logic of intermediary arrangements (Howoldt, 2024).

Methodologically, this study employs a two-phase, structure-oriented comparative strategy. The first phase links cross-national differences in innovation system conditions to the formation of intermediary-centered policy configurations; the second assesses how these role structures are associated with subsequent system-level innovation performance. Rather than modeling longitudinal processes or within-country trajectories, the analysis uses cross-sectional and temporally separated data points to capture how structural role assignment functions across different institutional contexts. This approach enables a mid-level comparison of policy architectures and highlights the analytical value of role-centered configurations in revealing embedded coordination logics, thus advancing the study's initial analytical aims regarding role structure and system alignment.

Future research may expand on this study in several directions. First, the empirical scope is limited to policy measures that explicitly designate intermediaries as target groups. As a result, the findings do not reflect the broader set of innovation policies that may engage intermediaries indirectly or in latent ways. Second, while the Global Innovation Index offers a comprehensive measure of innovation system performance, its composite structure and annual cross-sectional design constrain the ability to trace longitudinal dynamics or causal processes. Third, although the current version of the STIP Compass database includes more detailed classifications of intermediary actors compared to earlier iterations, the taxonomy remains coarse. It distinguishes only five intermediary types without further disaggregation by function, sectoral affiliation, or institutional form. These limitations suggest the need for future studies to incorporate more granular role typologies, consider longer policy horizons, and explore how intermediary configurations affect implementation outcomes in practice.

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Appendices

Appendix A

Variable definitions and sources.

Variable name	Definition	Comment	Source
TLDs/pop.	Number of generic top-level domains registered per 1,000 people aged 15 to 69.		Leogrande, 2024a; WIPO, 2024
Env_cert/GDP	Number of ISO 14001 environmental certificates per billion PPP-adjusted GDP.		Leogrande, 2024b; WIPO, 2024
NewBiz/pop.	Number of new business registrations per 1,000 working-age individuals.		WIPO, 2024
Software/GDP	Software spending as a percentage of GDP.	Author's calculation. GII sub-indicators are normalized to the [0, 1] interval by dividing original scores (0–100) by 100.	WIPO, 2024
GovFund/pupil	Government funding per pupil in tertiary education as a share of GDP per capita.		WIPO, 2024
VC_deals/GDP	Venture capital deals as a percentage of GDP.		Leogrande, 2024d; WIPO, 2024
PISA_scores	PISA scores measuring 15-year-old student performance in reading, mathematics, and science.		Leogrande, 2024c; WIPO, 2024

High-tech Exports (Share of GDP)	High-technology exports are products with high R&D intensity, such as aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.	Author's calculation based on data on high-tech exports and GDP (current US\$) from World Bank.	
Manufacturing VA (Share of GDP)	Manufacturing refers to industries in ISIC divisions 15–37. Value added is the net output of a sector after adding outputs and subtracting intermediate inputs.	World Bank national accounts data, OECD National Accounts data files.	
Population (log)	Log of population size		World Bank population data.
Policy Budget	Numerical coding of annual policy budget, based on the categorical ranges reported in the survey: “Less than 1M EUR” = 0.005; “1M–5M EUR” = 0.01; “5M–20M EUR” = 0.05; “20M–50M EUR” = 0.2; “50M–100M EUR” = 0.5; “100M–500M EUR” = 1; “More than 500M EUR” = 5; “Not applicable” = 0; “Unknown” or missing = NA.	Based on “Yearly budget range in EUR” of each policy in the Sample (Data From STIP Compass; coded manually by author).	Howoldt (2024), Characterising innovation policy mixes in innovation systems, Research Policy, Table A2.
OECD Member	Dummy variable indicating OECD membership each year.	1 = member; 0 = non-member, varies by year	OECD (https://www.oecd.org/about/document/ratification-oecd-convention.htm)
Federalism (dummy)	Countries included in the list of federal countries on the website of the Forum of Federations, an international organisation seated in Canada supported by many federal countries.	1 = federalism; 0 = non-federalism, varies by year	Forum of Federations (http://www.forumfed.org/countries/)
EU Member	Dummy variable indicating EU membership each year.	1 = member; 0 = non-member, varies by year	EU (https://european-union.europa.eu/about-eu/countries_en)

Source: compiled by the author

Appendix B

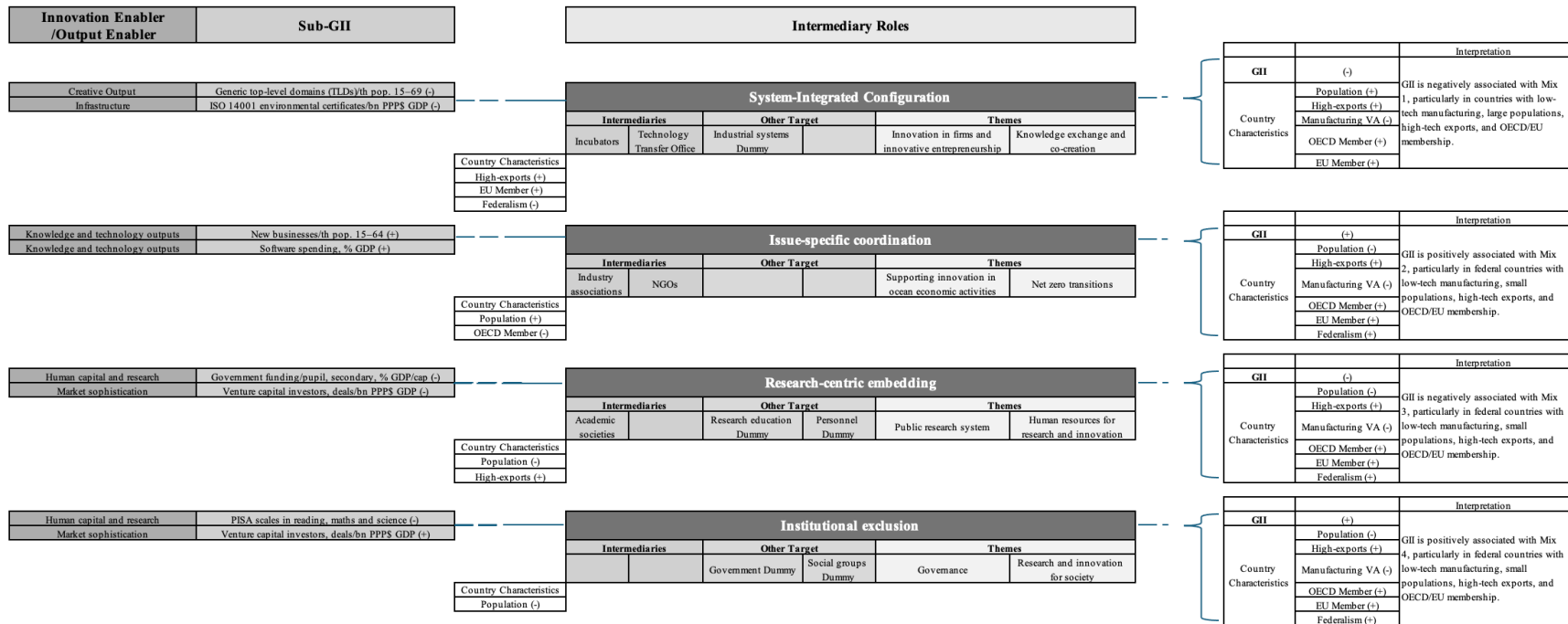
Policy Mix Dummy Definitions

Variable Name	Definition	Source
Incubators	Equals 1 if the target group includes “Incubators, accelerators, science parks or technoparks”	
Industryassociations	Equals 1 if the target group includes “Industry associations”	
Academicsocieties	Equals 1 if the target group includes “Academic societies / academies”	
Technologytransferoffices	Equals 1 if the target group includes “Technology transfer offices”	
NGOs	Equals 1 if the target group includes “Non-governmental organisations (NGOs)”	
Intermediary_D	Equals 1 if any of the following are present: “Incubators, accelerators, science parks or technoparks”, “Industry associations”, “Academic societies / academies”, “Technology transfer offices”, “Non-governmental organisations (NGOs)”	
Government_D	Equals 1 if any of the following are present: “National government”, “Subnational government”, “International entity”	
Researcheducation_D	Equals 1 if any of the following are present: “Higher education institutes”, “Public research institutes”, “Private research and development lab”	
Personnel_D	Equals 1 if any of the following are present: “Established researchers”, “Postdocs and other early-career researchers”, “Teachers”, “PhD students”, “Undergraduate and master students”, “Secondary education students”, “Programme managers and other research support staff”	
Industrialsystems_D	Equals 1 if any of the following are present: “Entrepreneurs”, “Private investors”, “Labour force in general”, “Firms of any size”, “SMEs”, “Micro-enterprises”, “Multinational enterprises”, “Firms of any age”, “Young firms (1 to 5 years old)”, “Nascent firms (0 to less than 1 year old)”, “Established firms (more than 5 years old)”	
Socialgroups_D	Equals 1 if any of the following are present: “Civil society”, “Women”, “Disadvantaged and excluded groups”	

OECD STIP
Compass
Database
(<https://stip.oecd.org/stip/>)

Source: compiled by the author

Appendix C Visualized Summary of the Results



Source: compiled by the author

Appendix D

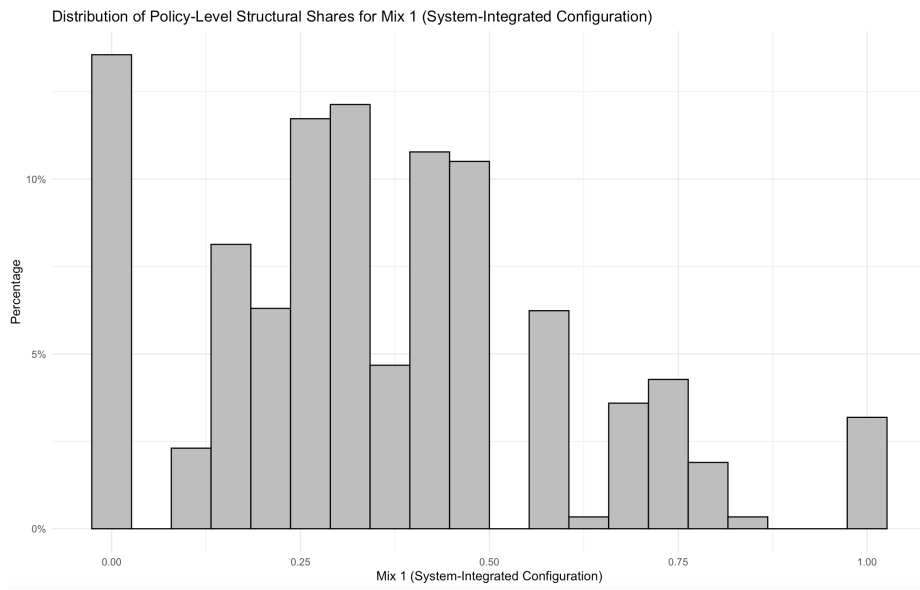


Figure 4. Distribution of Policy-Level Structural Shares for Mix 1 (System-Integrated Configuration)

Source: compiled by the author

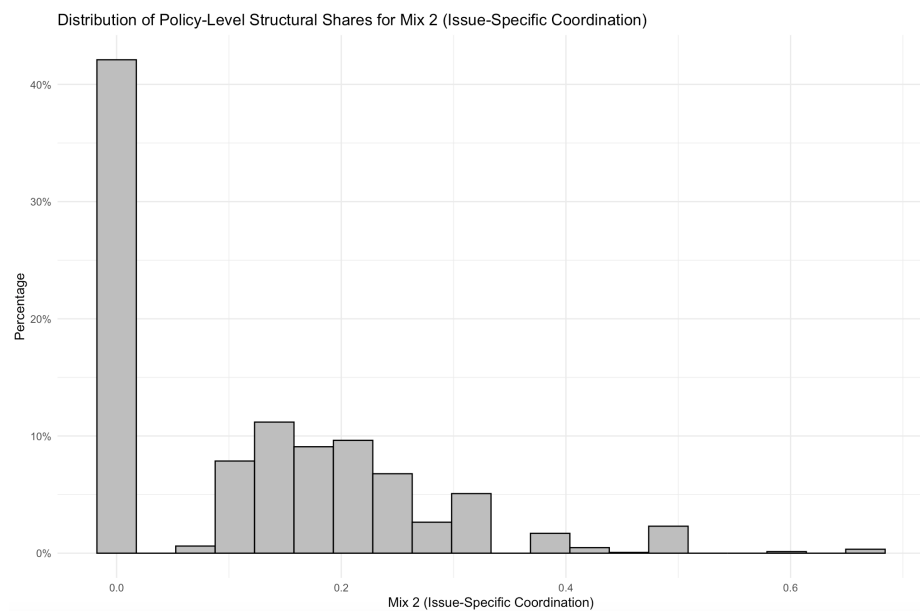


Figure 5. Distribution of Policy-Level Structural Shares for Mix 2 (Issue-Specific Coordination)

Source: compiled by the author

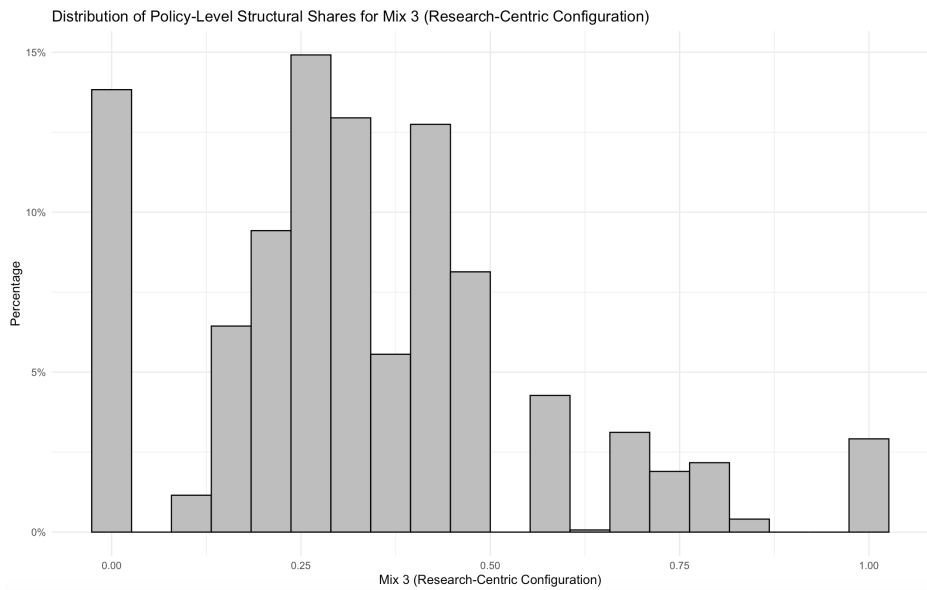


Figure 6. Distribution of Policy-Level Structural Shares for Mix 3 (Research-Centric Configuration)

Source: compiled by the author

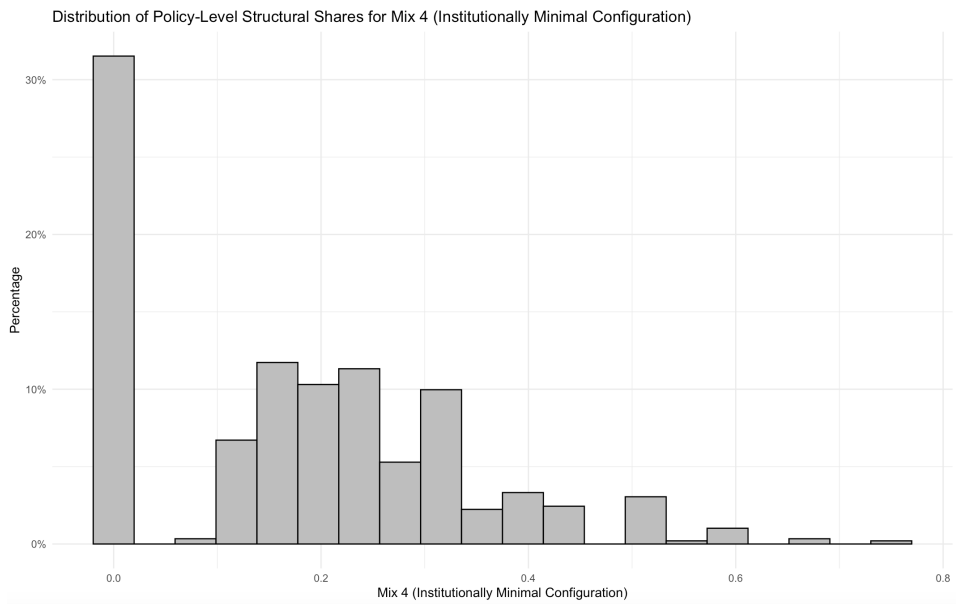


Figure 7. Distribution of Policy-Level Structural Shares for Mix 4 (Institutionally Minimal Configuration)

Source: compiled by the author

Appendix E

Resümee

VAHENDUSORGANISATSIOONIDE ROLLIDE STRUKTUREERIMINE INNOVATSIOONIPOLIITIKA KOMPLEKTIDES: MITME RIIKI POLIITIKATASANDI ANALÜÜS KOORDINEERIMISE JA TULEMUSLIKKUSE KOHTA

Xuhua Huang

See uurimus käsitleb, kuidas innovatsiooni vahendajad on riiklikes poliitikakombinatsioonides struktuurselt configureeritud ning kuidas need konfiguratsioonid on seotud süsteemitasandi innovatsiooni tulemuslikkusega. Tuginedes 1049-le vahendajatele suunatud poliitikameetmele 54 riigis ajavahemikus 2013–2024, tuvastab analüüs neli korduvat struktuuri: süsteemiga lõimitud rollid, mille eesmärk on killustunud juhtimise ületamine; probleemipõhised korraldused, mis on põimitud sihipärastesse ümberkujundamisvaldkondadesse; teaduskesksed konfiguratsioonid, mis on suunatud akadeemilistele alasüsteemidele; ja kujundused, kus vahendajad on struktuurselt välja jäetud. Kaheetapiline empiiriline strateegia seob riiklikud süsteemiomadused nende struktuuride kujunemisega ning uurib nende seoseid täheldatud innovatsioonitulemustega. Tulemused näitavad, et temaatiliselt piiritletud ja võimekusele vastavates kontekstides põimitud vahendajate rollid toetavad pigem kooskõlalist süsteemset toimimist, samas kui killustunud või sisekesksetes konfiguratsioonides juurdunud rollid on institutsionaalselt piiratud oma koordineerimisvõimekuses. Edasine analüüs näitab, et nende rollistruktuuride mõju ei ole ühtne, vaid seda kujundab laiem valitsemiskeskond, kus institutsionaalsed režiimid ja absorbeerimisvõime tingivad nende süsteemse panuse. Vahendajaid käsitledes mitte kui fikseeritud tegijatüüpe, vaid kui struktuurselt määratud koordineerimisrolle, edendab see uurimus konfiguratsioonipõhist arusaama innovatsioonipoliitikast ning pakub struktuurset vaatenurka, kuidas rahvuslikud süsteemid koordineerimisfunktsioone jaotavad ja hoiavad.

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