frontiers | Frontiers in Political Science

TYPE Original Research
PUBLISHED 11 November 2025
DOI 10.3389/fpos.2025.1698386

OPEN ACCESS

EDITED BY
Stacey M. Mitchell,
Georgia State University, United States

REVIEWED BY
Yilin Kang,
South Central of University for Nationalities, China
Hannes Thees,
Catholic University of Eichstätt-Ingolstadt, Germany

*CORRESPONDENCE
Chunning Wang
✉ p2424662@mpu.edu.mo

RECEIVED 04 September 2025
ACCEPTED 27 October 2025
PUBLISHED 11 November 2025

CITATION
Hu H, Yin Y, Xie Y, Cai J and Wang C (2025) Functional differentiation pyramid and adaptive reconstruction: a computational analysis of multi-level governance in China's policy experimentation zones.
Front. Polit. Sci. 7:1698386.
doi: 10.3389/fpos.2025.1698386

Functional differentiation pyramid and adaptive reconstruction: a computational analysis of multi-level governance in China's policy experimentation zones

Haoqian Hu[1], Yifen Yin[1], Yingchong Xie[2], Jingwen Cai[1] and Chunning Wang[1]*

[1]Faculty of Humanities and Social Sciences, Macao Polytechnic University, Macao SAR, China, [2]School of Mathematics and Statistics, Beijing Institute of Technology, Beijing, China

Reconciling strategic alignment with local innovation is a core governance challenge for policy experimentation zones worldwide. This study investigates this challenge by elucidating the operational dynamics of multi-level governance in China, using the unique Guangdong-Macao In-depth Cooperation Zone in Hengqin as a natural laboratory for institutional experimentation. Integrating semantic network analysis (SNA) and Latent Dirichlet Allocation (LDA) topic modeling, we systematically analyze 623 policy documents from 2009 to 2024, spanning four administrative levels: national, provincial, municipal, and cooperation zone. Our findings reveal a "functional differentiation pyramid" governance architecture, where the national level provides strategic guidance, while lower-level governments engage in significant issue disaggregation and reorganization during implementation. We find that policy transmission across levels is not a linear replication but a dynamic process we term "adaptive reconstruction"—a form of institutional work actively undertaken by subnational governments to enhance policy fitness. We argue that this mechanism is key to how the governance system simultaneously maintains strategic coherence and local flexibility. The results provide new empirical evidence for multi-level governance (MLG) theory. This "Hengqin model" contributes to global governance debates by empirically demonstrating a distinct architecture for policy implementation, while also showcasing the potential of computational social science in policy analysis.

KEYWORDS

multi-level governance, policy experimentation zone, adaptive reconstruction, policy transmission, Hengqin

1 Introduction

Policy pilot zones, as a key instrument for advancing institutional reform and economic development, have become a prevalent governance practice worldwide. From special economic zones to free trade zones, governments have sought to explore innovative pathways and manage reform risks by delineating specific territories and granting them policy autonomy. The governance of these zones, however, is invariably confronted with a core intrinsic tension: how to strike a delicate balance between the "top-down coordination" needed to ensure alignment with national macro-strategies and the "bottom-up adaptation" required to stimulate local innovation and ensure effective policy implementation. On one hand, a lack of effective top-down coordination can lead to policy fragmentation and goal divergence. On the

other hand, excessively rigid central control can suppress local initiative, depriving policy experiments of their essential value. Constructing a governance architecture that can effectively reconcile this tension is a pressing and universal challenge in the fields of public administration and policy sciences.

In the global landscape of this challenge, China offers a particularly complex and valuable case for examination. Its gradualist reform process, famously described as "crossing the river by feeling the stones," is, in essence, a history of continuously establishing and adjusting various policy pilot zones (Nair and Howlett, 2016). These zones are not merely engines of economic growth but also concentrated embodiments of China's distinctive governance model. Unlike in many federal states, policy experimentation in China unfolds within a unitary framework where strong central authority coexists with a high degree of local government agency. Local governments act as both faithful executors of central strategies and proactive innovators driven by political incentives and "promotion tournaments," leading their efforts to be characterized as "experimentation under pressure" (Heilmann, 2008; Teets et al., 2017). Under these unique central-local interactive dynamics, the process by which policy agendas are transmitted, adapted, and reconstructed across multiple governmental levels offers an exceptional window into the complexities of contemporary state governance.

Existing theories provide multiple perspectives for understanding this complex process, yet they also have their limitations. The theory of multi-level governance (MLG) offers a core analytical framework for the dispersion of authority and interaction across governmental tiers (Piattoni, 2009; Klein and Xhaferi, 2024). In particular, Hooghe and Marks' (2003) classic distinction between type I governance (territorially based, hierarchically structured, general-purpose) and type II governance (functionally based, networked, task-specific) has provided vital tools for understanding governance configurations that transcend traditional state-centrism. However, the explanatory power of MLG theory faces unique challenges when applied to unitary states like China, a context that moves beyond the concept's original Western application. While Hooghe and Marks' (2003) distinction remains a vital tool, the field has advanced significantly. Recent scholarship confirms that Chinese governance is not a simple hierarchy but a complex interplay. For instance, recent studies have empirically confirmed and extended the Type I and Type II definitions by analyzing the hybrid vertical and functional interactions in China's public health responses (Yao et al., 2022). Others have shown how strong central coordinating authority (Type I) and continuous multi-level negotiation (Type II) dynamically coexist in specific policy fields like green finance (Cheng and Zhang, 2024). Despite this clear progress on sector-specific dynamics, the overarching governance architecture by which these Type I and Type II features fuse within a complex, cross-domain policy experimentation zone like Hengqin remains empirically underexplored.

Similarly, theories of policy diffusion and transmission have systematically identified various mechanisms for the intergovernmental flow of policy innovations—such as "learning" based on rational assessment, "imitation" to seek legitimacy, "competition" to gain a relative advantage, and "coercion" stemming from power asymmetries (Simmons et al., 2006; Gilardi and Wasserfallen, 2019). However, their theoretical focus often lands on the binary outcome of whether a policy is adopted. In studies of vertical diffusion, existing models tend to conceptualize subnational governments as passive recipients of policy, paying insufficient attention to the profound transformations policy content undergoes during transmission (Zhang and Zhu, 2020; Ye and Wu, 2024). In reality, policy implementation is, in itself, a process of re-creation. Subnational governments do not simply replicate directives from above; they engage in active "policy translation" based on local contexts and their own interests (Sausman et al., 2016). This adaptive adjustment at the implementation level is not a signal of transmission failure but rather a necessary form of "institutional work"—an innovative reconstruction undertaken by actors to ensure the local applicability and effectiveness of a policy (Breit et al., 2016). Nevertheless, the specific process of this reconstruction—how policy agendas are systematically filtered, decomposed, and reassembled—remains an unresolved question.

Furthermore, institutional theory offers profound insights into the underlying drivers of policy evolution. Whether it is behavioral convergence under the pressure of institutional isomorphism (DiMaggio and Powell, 1983), the conflict and adaptation arising from the coexistence of multiple institutional logics (Thornton and Ocasio, 2008), or the role of "critical junctures" in reshaping development paths (Mahoney, 2000), all point to a core fact: policy evolution is not an isolated, technical process but is deeply embedded in a complex institutional context. However, these powerful conceptual tools are often used to explain system stability (e.g., path dependency), homogenization (e.g., isomorphism), or macro-level changes. For an emerging and significant field of institutional innovation like a policy pilot zone, how a coherent, multi-level policy system with a clear division of labor is dynamically constructed ex nihilo—how its internal policy networks are formed, how its core themes evolve, and what specific roles institutional elements play in this generative process—requires more fine-grained empirical investigation.

In summary, these three theoretical streams provide a complementary analytical lens for this study. We argue that MLG theory offers the foundational "structural scaffold" for the Hengqin system. Policy diffusion/transmission theory then helps explain the "process dynamics" that occur within this structure (i.e., how "adaptive reconstruction" happens). Finally, Institutional Theory reveals the "deep drivers" shaping this process, such as how "critical junctures" trigger change or competing "institutional logics" define the content of local adaptation.

In light of this, the present study seeks to explore the following core questions: First, within the multi-level governance structure of China's policy pilot zones, what structural characteristics and thematic distributions do policy texts at different administrative levels exhibit? Second, how are policy agendas transmitted, diffused, and adapted across these levels, and what patterns of consistency or divergence do they reveal? Third, how do unique institutional arrangements, such as cross-border cooperation and joint management, influence policy content, structure, and the logic of inter-level interactions?

To address these questions, this study selects the Guangdong-Macao In-depth Cooperation Zone in Hengqin (hereafter referred to as the "Hengqin Cooperation Zone") as its case. Hengqin is not only one of China's most recent national-level policy pilot zones but also a unique arena for exploring the deep alignment of rules between the mainland and Macao under the "One Country, Two Systems" framework. Its new system of "joint consultation, joint construction, joint management, and shared benefits" (Tang et al., 2022; Lin et al., 2024) makes it an ideal "natural laboratory" for observing the tension

between "coordination" and "adaptation." This study innovatively employs computational social science methods, integrating semantic network analysis (SNA) and Latent Dirichlet Allocation (LDA) topic modeling, to conduct a deep mining of 623 policy documents (2009–2024) spanning four administrative levels: national, provincial, municipal, and the Cooperation Zone itself. SNA is employed to reveal the "structural skeleton" of policy issues, while LDA is used to fill in their "substantive flesh" (Shim et al., 2015). The combination of these methods enables us to systematically delineate the operational landscape of the governance architecture in China's policy pilot zones.

The core argument of this study is that the governance architecture of China's policy pilot zones exhibits a unique structure we term the "functional differentiation pyramid." In this structure, "top-down coordination" is achieved through macro-level, framework-oriented strategic planning that ensures directional consistency. Concurrently, "bottom-up adaptation" is accomplished through a series of actions by subnational governments during implementation, including significant issue specification, community restructuring, and thematic focusing. We conceptualize this process as "adaptive reconstruction"—a form of "institutional work" proactively undertaken by lower-level governments during policy transmission to enhance policy fitness and operability. It is this mechanism of "adaptive reconstruction," we argue, that allows the governance system to simultaneously maintain strategic coherence and local flexibility. The remainder of this paper is organized as follows: Section 2 details the data sources and research methodology; Section 3 presents the detailed empirical results; Section 4 offers an in-depth theoretical discussion of the findings; and finally, Section 5 concludes the study and puts forward policy implications.

2 Research design and methods

To systematically deconstruct the multi-level policy architecture of the Hengqin Cooperation Zone and to elucidate its internal operational mechanisms, this study employs a research design that integrates computational methods with qualitative interpretation. The overall research framework is illustrated in Figure 1. This chapter elaborates on the data sources and screening criteria, the text preprocessing workflow, and the core analytical techniques employed in this study: SNA and LDA topic model.

2.1 Data sources and sample screening

The empirical analysis of this study is grounded in a purpose-built policy text corpus spanning four administrative levels. The collection and screening of data followed a rigorous, standardized process to ensure its comprehensiveness, relevance, and validity.

Data Collection: The policy text data were primarily sourced from "PKULaw," an authoritative legal and regulatory database in China. Using "Hengqin" as the core keyword, we retrieved all relevant policy documents within a timeframe extending from August 14, 2009 (the date the State Council formally approved the Overall Development Plan for Hengqin) to December 31, 2024 (the data collection endpoint

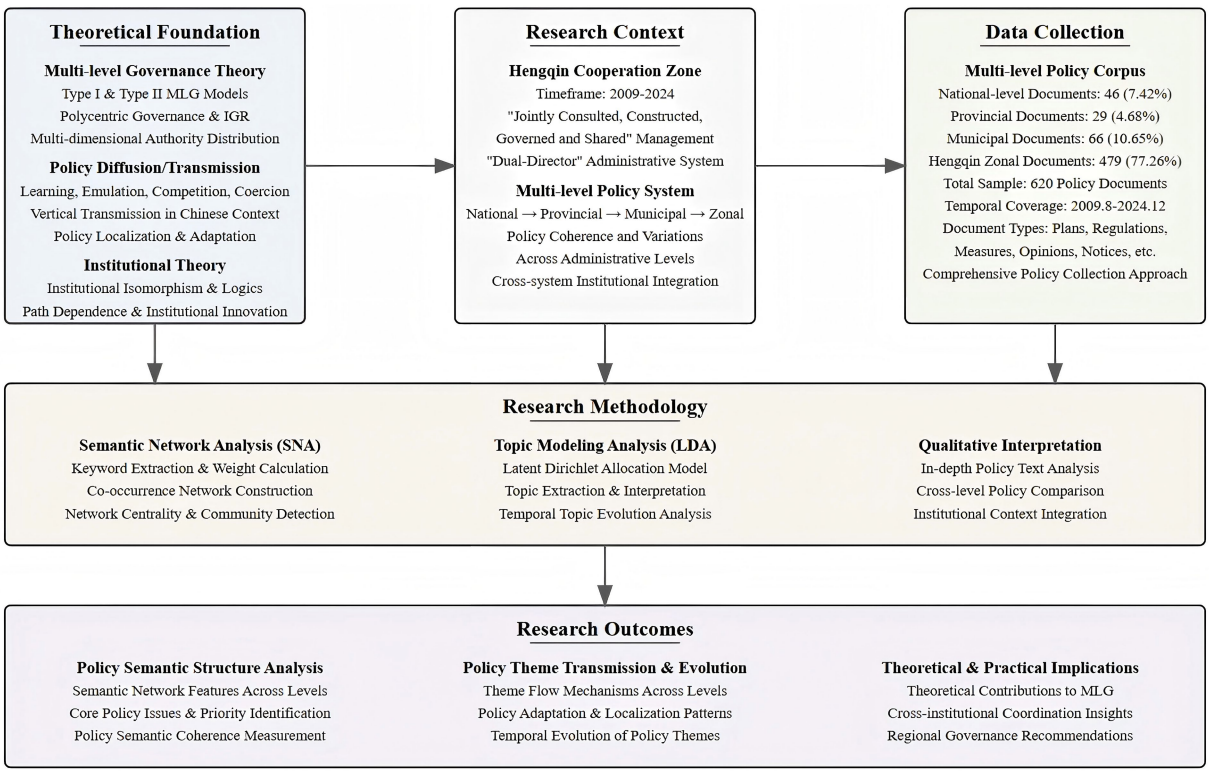

FIGURE 1
Research framework.

set for this study to cover policy developments following the zone's closed customs operations).

Sample screening: To ensure analytical precision, the vast number of initially retrieved documents were refined through the following four-step screening protocol:

(1) Issuing body screening: the issuing authorities of the policies were strictly limited to the central government of the People's Republic of China and its functional departments; the Guangdong Provincial Government and its functional departments; the Zhuhai Municipal Government and its functional departments; and the administrative bodies of the Hengqin Cooperation Zone (including the Hengqin New Area prior to September 2021). All unofficial documents, such as academic research, news reports, and media interpretations, were excluded.
(2) Policy type screening: text types were restricted to official policy documents with guiding, normative, and universally binding force, primarily including plans, schemes, regulations, measures, opinions, notices, and announcements. Non-universal or purely procedural documents, such as personnel appointments and dismissals, meeting minutes, and one-off event notices, were removed.
(3) Content relevance screening: through manual review, each selected document was verified to ensure its core content was directly related to the research themes of Hengqin's regional development, industrial planning, institutional innovation, or Guangdong-Macao cooperation.
(4) Text standardization: all valid policy texts underwent uniform formatting to extract their plain text content, which was then proofread to ensure completeness and accuracy. For policies with multiple versions (e.g., revised editions), this study uses the most recently published version.

Following this procedure, a final sample of 623 valid policy texts was established. Of these, 46 (7.38%) are national-level policies, 29 (4.65%) are provincial-level, 69 (11.07%) are municipal-level, and 479 (77.26%) are district-level (Cooperation Zone/New Area).

As depicted in Figure 2, the temporal distribution of policy publications aligns closely with Hengqin's developmental stages. Notably, following the "critical juncture" of the 2021 the overall plan for the construction of the Guangdong-Macao In-depth Cooperation Zone in Hengqin (Central Committee of the Communist Party of China and State Council, 2021), the volume of district-level policy texts exhibited exponential growth. This distributional characteristic not only validates the dynamic sensitivity of our corpus but also furnishes a solid empirical foundation for the subsequent analysis of how institutional change affects policy agendas.

2.2 Methods of analysis

2.2.1 Text preprocessing

High-quality text preprocessing is the cornerstone of the validity of all subsequent computational analyses. To convert the unstructured policy texts into structured data suitable for analysis, all 623 documents in the corpus underwent a uniform preprocessing procedure. This process included the following steps: (1) Word segmentation: The Jieba library in Python was employed for Chinese word segmentation. To enhance

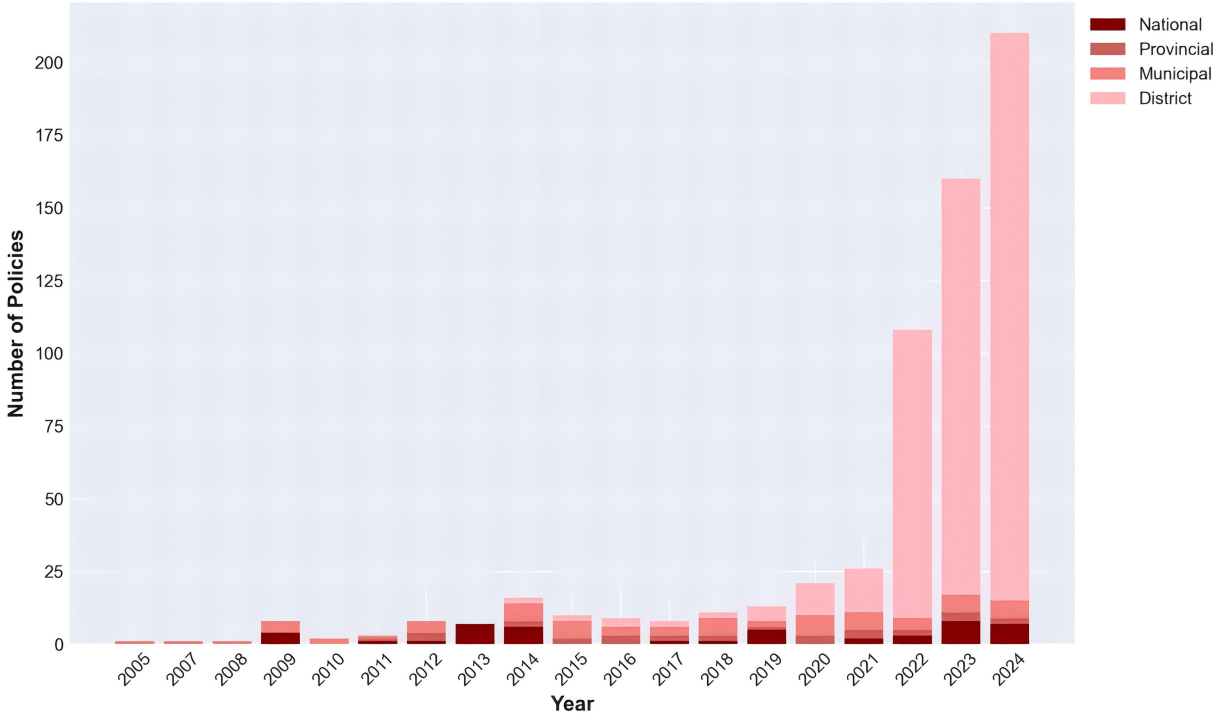

FIGURE 2
Cumulative distribution of policies for the Guangdong-Macao In-depth Cooperation Zone in Hengqin by level (2005–2024).

segmentation accuracy, a custom dictionary was incorporated. This dictionary includes Hengqin-specific terminology (e.g., "tiered management," "Macau New Neighbourhood"), common policy vocabulary, and names of official institutions. (2) Part-of-speech (POS) tagging and filtering: The segmented results underwent part-of-speech (POS) tagging. Subsequently, the data was filtered to retain only content words—such as nouns, verbs, and adjectives—that carry core semantic meaning. (3) Stop words removal: A customized stop word list was developed to remove words with low semantic contribution. This list was built upon the Harbin Institute of Technology (HIT) stop word list and augmented with high-frequency administrative terms specific to policy texts (e.g., "according to," "in accordance with"). (4) Term normalization: Terms with identical meanings but variant expressions were consolidated. For instance, variants such as "Cooperation Zone" were all standardized to a single representative term for the "Guangdong-Macao In-depth Cooperation Zone in Hengqin." Additionally, the names of official bodies were normalized in accordance with official institutional reform plans.

2.2.2 Semantic network analysis (SNA)

This study employs SNA to reveal the internal structure of policy issues and their variations across different administrative levels. In this approach, we treat policy keywords as "nodes" and their co-occurrence within the same document as "edges." By constructing such a semantic network, we can visually identify which policy issues are central (centrality), which issues tend to cluster together (community detection), and thus reveal the "structural skeleton" of the policy framework. This method allows for the intuitive visualization of policy frameworks, the identification of core issues, and the exploration of associative patterns among them (Breit et al., 2016; Shim et al., 2015).

Keyword extraction and network construction: For this study each individual policy document serves as the basic unit for co-occurrence analysis. First the Term Frequency-Inverse Document Frequency (TF-IDF) algorithm is utilized to extract key terms from the corpus of each administrative level. TF-IDF effectively measures the importance of a term within a document relative to the entire corpus (Dzisevič and Šešok, 2019). The formula is as follows:

$$\mathrm{TF-IDF}(w,d) = \mathrm{TF}(w,d) \times \mathrm{IDF}(w)$$

where $\mathrm{TF}(w,d)$ is the frequency of term w in document d, $\mathrm{IDF}(w) = \log \frac{N}{\mathrm{DF}(w)+1}$, N is the total number of documents, and $\mathrm{DF}(w)$ is the number of documents containing the term w. Subsequently, if two key terms appear within the same policy document, a co-occurrence relationship is established between them. By calculating the co-occurrence frequency of all keyword pairs, an undirected weighted keyword co-occurrence network $G = (V, E)$ is constructed, where V is the set of keyword nodes, E is the set of edges, and the weight of edges is determined by the co-occurrence frequency. It should be noted that the nodes in the network represent unique policy keywords extracted via TF-IDF, not the policy documents themselves. Therefore, while a larger corpus at the district level provsssswides a richer basis for keyword extraction, the growth in the number of nodes substantively reflects an increase in the thematic complexity and granularity of the policy agenda at the grassroots level.

Analysis of network structural features: To conduct an in-depth analysis of the policy network structure at each administrative level, this study measures three key categories of network metrics:

(1) Global network metrics: these include network size (the number of nodes and edges), network density (Yi and Scholz, 2016), average path length, and average clustering coefficient (Sosa et al., 2020). These metrics are used to provide a macroscopic assessment of the policy agenda's richness, the tightness of issue linkages, the efficiency of information transmission, and the clustering characteristics of themes.
(2) Node centrality metrics: we primarily measure degree centrality (Zhang et al., 2011), weighted degree centrality, and betweenness centrality (Leydesdorff, 2007). These metrics are used to microscopically identify policy issues that occupy central positions, exert significant influence, or play crucial "bridge" roles within the policy network.
(3) Community detection: the Louvain algorithm (Zhang et al., 2017) is employed for community detection within the network. This algorithm effectively identifies tightly-knit subgroups of nodes, which we term "policy-theme communities," thereby revealing the internal thematic structure of the policy agenda.

2.2.3 LDA topic modeling and thematic transmission analysis

If SNA reveals the "structural skeleton" of policy issues, then the LDA topic model is intended to fill in their "substantive flesh." LDA is an unsupervised, generative probabilistic model capable of automatically identifying latent, unobservable "topics" from large-scale text corpora (Schwarz, 2018). Its core assumption is that each policy document is a mixture of multiple topics (e.g., "finance" and "talent"), and each topic is, in turn, a probability distribution over a set of words (e.g., the topic "finance" might be defined by high-probability words like "bank," "cross-border," and "account").

Model construction and determination of topic number: To ensure model quality, we constructed separate LDA models for the sub-corpora of each of the four administrative levels. The determination of the number of topics (the K value) is a critical step in model construction. We adopted a hybrid approach that combines statistical metrics with manual interpretation. First, model performance was evaluated by calculating perplexity scores (Wallach et al., 2009) and coherence scores (Röder et al., 2015) for a range of K values. Typically, lower perplexity and higher coherence scores indicate a better-performing model. Second, we integrated these statistical results with a qualitative assessment of the high-frequency characteristic terms within each generated topic. This process also took into account the intrinsic characteristics of each policy level (e.g., higher-level policies feature more macroscopic themes, whereas lower-level policies are more specific). Through this method, the optimal number of topics was ultimately determined for the national, provincial, municipal, and district levels, respectively.

Thematic content and transmission analysis: After establishing the optimal number of topics for each level, we first summarized the high-frequency characteristic terms for each topic. These terms, combined with an in-depth reading of the relevant policy texts, formed the basis for manually labeling and interpreting each topic. Subsequently, to investigate the transmission and evolution of policy themes across different administrative tiers, this study employs cosine similarity based on word vectors. Specifically, each topic generated by LDA (defined as a set of weighted characteristic terms) is represented as a high-dimensional vector. We then calculate the pairwise cosine similarity between topic vectors from adjacent administrative levels. The resulting value ranges from [0, 1], where a value closer to 1 indicates greater semantic similarity between two topics. By setting an appropriate similarity threshold, we identified pairs of policy topics with significant semantic linkages across levels. This allowed us to construct a hierarchical transmission map of policy themes, visually revealing how policy priorities are transmitted, differentiated, and focused as they move from top-level design to grassroots implementation.

3 Results

This chapter systematically presents the core findings from the computational analysis of the multi-level policy texts concerning the Hengqin Cooperation Zone. First, we will leverage SNA to reveal the structural characteristics of policy issues and their hierarchical differentiation. Subsequently, we will employ the LDA topic model to conduct an in-depth analysis of the thematic distribution and intensity of policy content, as well as its cross-level transmission mechanisms.

3.1 The "pyramid" structure and functional differentiation of the policy network

The results of the SNA reveal that Hengqin's multi-level policy system is not structurally homogeneous. Instead, it exhibits a distinct configuration that we term the "functional differentiation pyramid." This structure is characterized by significant hierarchical differences in terms of network size, core issues, and community structure.

3.1.1 Overall structure: from high-level aggregation to rapid expansion

The global structural metrics for the policy network at each administrative level (see Table 1) vividly outline the macroscopic form of this "pyramid." From the national down to the Cooperation Zone level, the network size (measured by the number of nodes and edges) undergoes a dramatic expansion (see Table 1). It is important to note that while the Cooperation Zone level possesses a much larger document corpus (479 documents, compared to 46 at the national level), which provides a richer basis for keyword extraction, the growth in network nodes (from 47 at the national level to 205 at the district level) is not merely an artifact of corpus size. Rather, it substantively reflects a significant increase in the thematic complexity and granularity of the policy agenda at the grassroots. This expansion clearly illustrates the diffusion of the policy agenda from a high-level, condensed strategic framework into a multitude of fine-grained, operational issues at the final implementation stage.

Concurrently, network density shows a slight decrease from the top down, whereas the average clustering coefficient remains at an extremely high level across all tiers. This reveals a critical structural characteristic: although not all issues are directly interrelated at the grassroots level, they tend to form highly cohesive local "thematic clusters." The policy system as a whole is therefore not a loose collection of issues, but rather a system composed of multiple, tightly-coupled thematic blocks, which possesses a high capacity for efficient internal information transmission (as indicated by the extremely short average path length). Such a structure ensures the strategic focus of the top-level design while simultaneously providing the space for modularity and a specialized division of labor in grassroots implementation.

3.1.2 Core nodes: hierarchical issue focus and functional positioning

A centrality analysis of the core nodes within each level's network (see Table 2) further illuminates the logic of functional division inside the pyramid structure. Governments at different tiers play distinctly different roles in policy agenda-setting, clearly delineating a path of functional differentiation from "strategic formulation" to "regional coordination," and further down to "local implementation" and "specialized operation."

TABLE 1 Comparison of structural metrics for policy semantic networks at each level.

Metric	National level	Guangdong province	Zhuhai city	Hengqin cooperation zone
Number of nodes	47	26	39	205
Number of edges	1,076	325	722	20,141
Network density	0.995	1	0.974	0.963
Average degree	45.79	25	37.03	196.5
Average weighted degree	470.68	194.85	427.64	4004.34
Average clustering coefficient	0.996	1	0.986	0.972
Average weighted clustering coefficient	0.365	0.37	0.243	0.059
Number of connected components	1	1	1	1
Average path length	1.005	1	1.026	1.037
Network diameter	2	1	2	2

For brevity, some values have been rounded to three decimal places.

TABLE 2 Summary of core nodes and key centrality metrics in policy semantic networks at each level.

Level	Core nodes by weighted degree (partial list)	Key nodes by betweenness centrality (and value)	Key nodes by eigenvector centrality (and value)
National level	Construction (727), management (695), policy (687), enterprise (665), Hengqin (641)	Technological development (0.790)	Construction (0.217)
Guangdong province level	Management (309), development (288), Zhuhai City (274)	Training (0.484), foreign exchange (0.371)	Management (0.294)
Zhuhai municipal level	Zhuhai City (780), management (767), Hengqin New Area (739), service (674)	Arbitrators (0.571)	Zhuhai city (0.263)
Hengqin cooperation zone level	Guangdong-Macao In-depth Cooperation Zone in Hengqin (13846), Enterprise (11660), Unit (12354), Cooperation (12297)	Cross-border e-commerce (0.348)	Guangdong-Macao In-depth Cooperation Zone in Hengqin (0.206)

At the national level, the policy network's core is dominated by macro-level narratives such as "construction," "management," and "policy," reflecting its function of strategic guidance and top-level design. A particularly significant finding is that while "technological development" does not have the highest weighted degree, its betweenness centrality is exceptionally high. This suggests that innovation-driven development is not merely an independent policy domain but also a critical "structural bridge" that connects different sectors within the national strategy. Subsequently, at the provincial level, the network's focus shifts to coordinative issues like "management," "development," and "Zhuhai City," the latter corresponding to the subordinate government. Here, the extremely high betweenness centrality of two nodes—"training" (human capital) and "foreign exchange" (finance)—reveals that the core function of provincial policy is to bridge national strategy with local implementation. It achieves this by promoting institutional innovation in specific key areas (human capital and cross-border finance) to operationalize national strategies and guide municipal-level execution.

As the policy agenda descends to the municipal level, its content becomes more specific, focusing on local administration (e.g., "Zhuhai City," "Hengqin New Area") and "service" provision. A particularly insightful finding is the extraordinarily high betweenness centrality of the "arbitrators" node. This clearly indicates that within the municipal government's policy toolkit, establishing a law-based business environment, exemplified by commercial dispute resolution, serves as a key lever and a priority for advancing regional development and undertaking institutional innovation. Finally, at the Cooperation Zone level, the complexity and intensity of the network agenda peak. All core issues revolve around keywords such as "Guangdong-Macao In-depth Cooperation Zone in Hengqin," "enterprises," and "cooperation," reflecting a comprehensive focus on the Zone's core missions: its own construction, the cultivation of market entities, and the deepening of cooperation with Macao. This demonstrates that at the final implementation level, policy resources and attention become highly concentrated on accomplishing specific strategic tasks, confirming the role differentiation inherent in the multi-level governance system.

3.1.3 Community structure: the decomposition and specialization of the policy agenda

The community detection analysis of the policy networks (see Table 3) further reveals the process of decomposition and specialization that the policy agenda undergoes during its downward transmission. From the national to the Cooperation Zone level, the number of policy-theme communities steadily increases, and their substance shows a clear evolution from macro to micro, and from strategic to operational. At the national and provincial levels, the number of policy communities is small (two at each level), and their thematic substance is relatively broad—such as "Strategic Planning & Regional Development" at the national level and "Financial Innovation & Project Investment/Financing" at the provincial level—reflecting the focus of high-level policy on core strategic directions.

As we move down the hierarchy, the policy agenda is systematically decomposed. At the municipal level, the policy communities differentiate into three distinct clusters, with more targeted thematic blocks such as "Commercial Law & Arbitration Services" emerging, signaling the initial decomposition of policy at the local level. Finally, at the Cooperation Zone level, the policy agenda is thoroughly broken down into four highly specialized and operational communities: "Industrial & Financial Development," "Enterprise Services & Sci-Tech Innovation Support," "Planning, Construction & Governance Supervision," and "Hengqin-Specific Features & Livelihood Services." The division of these communities closely aligns with the core tasks set forth in the Master Plan for the Construction of the Guangdong-Macao In-depth Cooperation Zone in Hengqin (Central Committee of the Communist Party of China and State Council, 2021), providing strong evidence that top-level designs are transformed at the grassroots level into a series of concrete, operational, and mission-oriented policy clusters. This evolutionary path of the community structure provides structural evidence for this study's core argument of "adaptive reconstruction"—that is, the macro-strategic intentions of higher-level governments are ultimately implemented through a systematic process of issue decomposition and reorganization at the subnational government level.

3.2 The content, evolution, and transmission of policy themes

If SNA revealed the "structural skeleton" of policy issues, then the LDA topic model fills in their "substantive flesh" from a content perspective. It clearly demonstrates the substantive focus of the policy agenda at each level, as well as the evolution of these focuses over time and their transmission across hierarchies.

TABLE 3 Thematic communities in the policy semantic networks at each level and their core features.

Level	Community ID	Community name (proposed)	No. of nodes	Sample core terms (partial list)
National	0	Strategic Planning & Regional Development	27	Research, region, talent, development, Guangdong-Hong Kong-Macao, planning, economy, cooperation, industry, finance, technology, service, international, cross-border
	1	Cooperation Zone Construction & Management Implementation	20	Management, State Council, Macao, construction, policy, Hengqin, project, platform, supervision, enterprise, customs, facilities, Guangdong-Macao In-depth Cooperation Zone in Hengqin
Guangdong Province	0	Financial Innovation & Project Investment/Financing	13	Account, funds, pilot, foreign exchange, bank, construction, financing, project, capital, business
	1	Regional Coordination & Business Environment	13	Enterprise, Hengqin, Zhuhai City, management, development, training, Hengqin New Area, department, service, cooperation, Guangdong Province, Macao
Zhuhai city	0	Commercial Law & Arbitration Services	4	Arbitrator, arbitration, party, arbitral tribunal
	1	Economic Development & Administrative Management	12	Economy, unit, department, reform, policy, industry, investment, administrative committee, project, headquarters
	2	Open Cooperation & Comprehensive Services	23	Customs, enterprise, Zhuhai city, management, business, development, law, service, construction, Hengqin, national, Macao, international
Hengqin cooperation zone	0	Industrial & Financial Development Community	56	Finance, cross-border, talent, headquarters, economy, preferential policies, industrial development, investment, financing, entrepreneurship, park, cross-border e-commerce
	1	Enterprise Services & Sci-Tech Innovation Support Community	40	Enterprise, rewards, procedures, support, technology, application materials, cooperation, Sci-tech, scientific research, service platform, economic development bureau, enterprise-benefitting
	2	Planning, Construction & Governance Supervision Community	76	Land, comprehensive, supervision, national, facilities, market, law, department, government, system, construction, planning, executive committee
	3	Hengqin-Specific Features & Livelihood Services Community	33	Hengqin, information, management, service, social, academic degree, interim measures, pandemic, qualification, Guangdong-Macao In-depth Cooperation Zone in Hengqin, livelihood affairs bureau

The sample core terms are a partial list selected to summarize the community's theme.

3.2.1 Core themes: division of labor in agendas across levels

The results of the topic model analysis (see Table 4) indicate a clear division of labor in the policy agendas across the four administrative levels, with each level forming distinct thematic clusters around its core functions. At the national level, topic intensity is highly concentrated on the "Overall Framework for Development & Construction," supplemented by themes such as "Regional Collaborative Development Strategy" and "Institutional Innovation & Regulatory Safeguards." Its core task is top-level design, establishing principles, and defining boundaries. The focus of provincial policy, in contrast, shifts to "Regional Collaborative Management," reflecting its role as a pivotal hub linking higher and lower levels, responsible for coordinating regional stakeholders and promoting "Financial Service Innovation" and "Industrial Development Support" in key areas.

Descending to the municipal level, the policy agenda is further specified into "Regional Development Planning," supplemented by a series of supporting themes such as "Guangdong-Macao Cooperation Affairs," "Commercial Legal Services," and "Comprehensive Supporting Services." Its role thus shifts to transforming macro-level plans into local actions and providing comprehensive local support. Finally, at the Cooperation Zone level, the policy agenda achieves the highest degree of focus and granularity. The theme with the greatest intensity, "In-depth Guangdong-Macao Cooperation," becomes the absolute core of all policies, giving rise to a multitude of highly specific, operational, and executive themes such as "Industrial Support," "Talent Introduction," and "Fiscal, Tax & Financial Support." This division of labor in the agenda, from macro-framework to concrete execution, reaffirms from a content perspective the "functional differentiation pyramid" governance structure.

3.2.2 Temporal evolution of themes: policy responses at critical junctures

The policy agenda is not static but responds dynamically to developmental stages and key events. The annual changes in the average intensity of policy themes at each level (see Figure 3) reveal these temporal evolutionary characteristics. At the national level, the intensity of the "Institutional Innovation & Regulatory Safeguards" theme shows significant peaks in 2011, 2017, and 2021. These moments closely correspond with critical junctures of institutional provision, such as the initial phase of Hengqin's development, the deepening of the Free Trade Zone policies, and the establishment of

TABLE 4 Policy themes, core keywords, and topic intensity at each level.

Level	Topic ID	Topic title (proposed)	Core keywords (sample)	Topic intensity
National	Topic 1	Industrial Innovation & Open Cooperation	Technology, tourism, platform, production, industry, international, tech development, service, enterprise, development, innovation, cooperation, Sci-tech, finance, trade, industrial park	0.013
	Topic 2	Regional Collaborative Development Strategy	Macao, mainland, city, industry, service, construction, management, international, development, cooperation, planning, Guangdong-Hong Kong-Macao, Bay Area, livelihood, transportation, integration	0.021
	Topic 3	Overall Framework for Development & Construction	Hengqin, cooperation, construction, goods, development, enterprise, service, management, customs, international, reform, innovation, opening-up, free trade zone, deepening, institution	0.229
	Topic 4	Institutional Innovation & Regulatory Safeguards	Customs, inspection, supervision, planning, import, management, national, mainland, technology, service, customs clearance, port, bonded, filing, facilitation, law	0.014
Guangdong Province	Topic 1	Financial Service Innovation	Bank, leasing, business, foreign exchange, financing, pilot, service, funds, account, finance, wealth management, account opening, settlement, loan, payment, cross-border	0.02
	Topic 2	Regional Collaborative Management	Cooperation, Guangdong Province, management, Macao, Hengqin, Zhuhai City, department, pilot, institution, business, government, approval, handling, implementation, filing	0.252
	Topic 3	Industrial Development Support	Enterprise, institution, project, construction, training, company, development, industry, talent, innovation, investment, service, support, subsidy, reward, park	0.025
Zhuhai city	Topic 1	Commercial Legal Services	Arbitration, arbitral tribunal, party, institution, investment, law, enforcement, rules, case, procedure, agreement, application, acceptance, mediation	0.009
	Topic 2	Regional Development Planning	Hengqin New Area, Zhuhai City, construction, development, administrative committee, tourism, cooperation, headquarters, planning, government, industry, project, park, city	0.219
	Topic 3	Guangdong-Macao Cooperation Affairs	Macao, Hengqin, cooperation, service, information, tourism, administrative committee, personnel, exchange, facilitation, mutual recognition, customs clearance, residents, joint construction	0.025
	Topic 4	Optimization of Administrative Management	Management, institution, industry, personnel, department, government, handling, approval, administrative, filing, registration, regulation, application, execution, supervision	0.008
	Topic 5	Comprehensive Supporting Services	Motor vehicle, customs, social, administrative committee, service, customs clearance, public, transportation, life, facilitation, security, port, supporting, livelihood	0.047
Hengqin cooperation zone	Topic 1	Institutional Operational Management	Unit, management, Hengqin New Area, Zhuhai City, institution, information, operation, registration, filing, administrative, supervision, regulation, approval, execution, system	0.031
	Topic 2	Talent Introduction & Cultivation	Talent, personnel, subsidy, management, investment, support, funds, training, professional, professional title, qualification, certification, evaluation, work, employment, housing	0.01
	Topic 3	Fiscal, Tax & Financial Support	Subsidy, support, funds, investment, reward, taxation, financing, loan, insurance, bank, credit, risk, guarantee, fiscal, grant, policy	0.009
	Topic 4	Industrial Support Policies	Project, subsidy, reward, support, Economic Development Bureau, industry, Sci-Tech, innovation, R&D, incubation, park, platform, base, carrier, demonstration	0.028
	Topic 5	In-depth Guangdong-Macao Cooperation	Cooperation, Guangdong-Macao In-depth Cooperation Zone in Hengqin, institution, Economic Development Bureau, Macao, innovation, deepening, joint construction, alignment, synergy, mutual recognition, facilitation, platform	0.245
	Topic 6	Comprehensive Supporting Services	Information, service, personnel, management, social, public, facilitation, livelihood, medical care, education, transportation, customs clearance, port, residence, security, facilities	0.037

the Cooperation Zone, reflecting the national level's role in shaping and strengthening the institutional framework at critical junctures.

At the provincial level, the "Regional Collaborative Management" theme held a dominant position during the initial launch of the Cooperation Zone (e.g., 2011) and showed renewed prominence during the critical periods of the new system's construction and operation (2021 and 2023). This highlights the provincial government's core role in coordination and promotion at major junctures. At the municipal level, the "Regional Development Planning" theme maintained a relatively high intensity across multiple years, indicating the municipal government's continuous efforts to guide development through planning.

The most significant dynamic changes occur at the Cooperation Zone level. In 2018, the intensity of the "In-depth Guangdong-Macao Cooperation" theme surged dramatically for the first time, marking a shift in policy focus from early foundational development toward deeper cooperation with Macao. Following the promulgation of the Overall Plan (Central Committee of the Communist Party of China and State Council, 2021) in 2021, the policy agenda at the

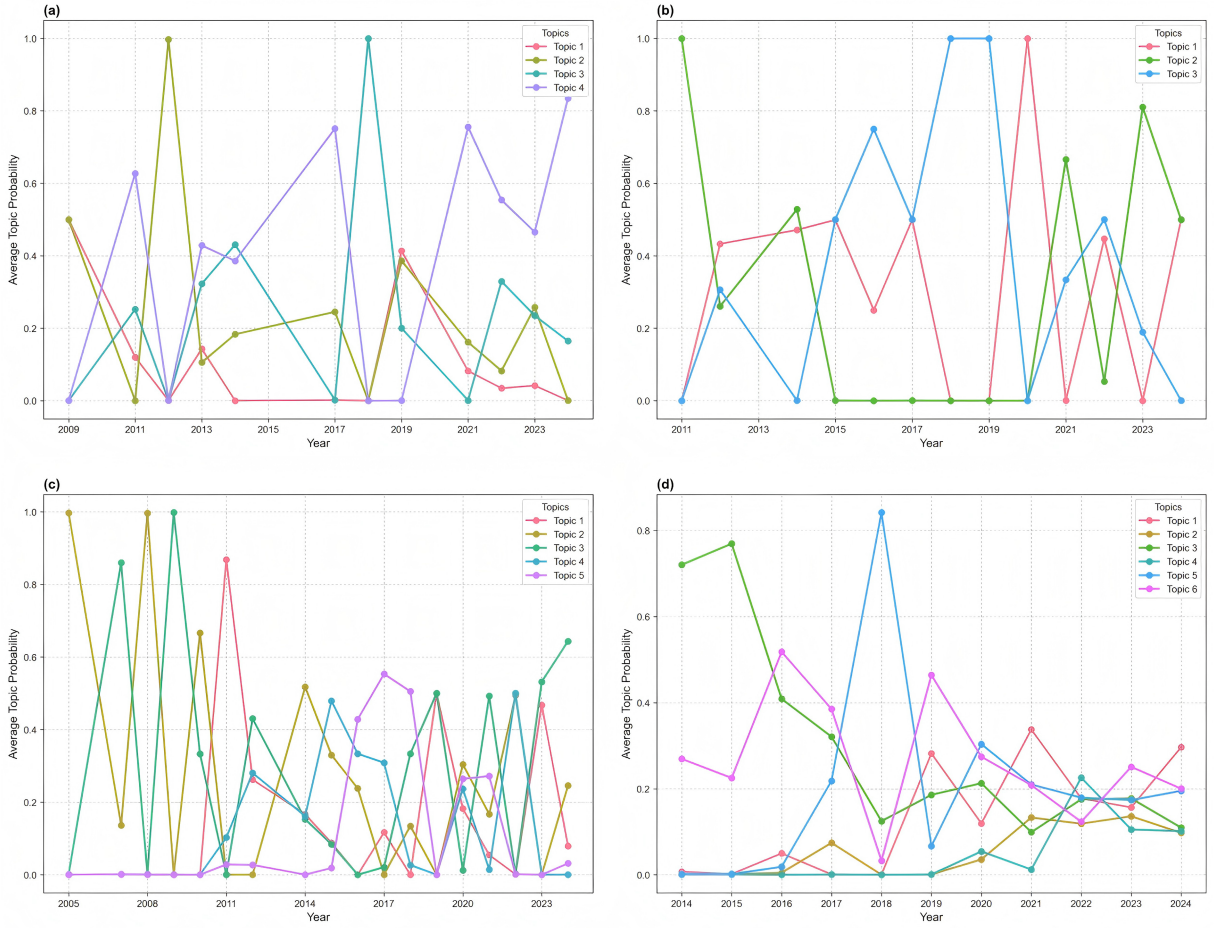

FIGURE 3
Evolution of average topic probabilities at each administrative level (2009–2024). The charts show the evolution for: **(a)** national level, where topics correspond to Topic 1 (industrial innovation & open cooperation), Topic 2 (regional collaborative development strategy), Topic 3 (overall framework for development & construction), and Topic 4 (institutional innovation & regulatory safeguards); **(b)** provincial level, with topics Topic 1 (financial service innovation), Topic 2 (regional collaborative management), and Topic 3 (industrial development support); **(c)** municipal level, covering Topic 1 (commercial legal services), Topic 2 (regional development planning), Topic 3 (Guangdong-Macao cooperation affairs), Topic 4 (optimization of administrative management), and Topic 5 (comprehensive supporting services); and **(d)** district level, with topics Topic 1 (institutional operational management), Topic 2 (talent introduction & cultivation), Topic 3 (fiscal, tax & financial support), Topic 4 (industrial support policies), Topic 5 (in-depth Guangdong-Macao cooperation), and Topic 6 (comprehensive supporting services). Each line represents a distinct policy topic, showing its average probability share within the respective level's policy documents for each year (see Table 4 for full details).

Cooperation Zone level was fully activated. This is visually corroborated by Figure 2, which shows an exponential growth in the volume of district-level policy texts after 2021. As shown in Figure 3d, multiple themes, including "Institutional Operational Management" and "Industrial Support Policies," advanced in parallel, presenting a complex practice of intensive and diverse policy innovation centered on the new mission. This dynamically adjusted policy portfolio vividly illustrates the agentic process of the local government continuously engaging in policy learning and adaptation in accordance with different developmental stages and practical needs while implementing the national strategy.

3.2.3 Cross-level transmission of themes: strategic consistency and adaptive reconstruction

The similarity analysis of policy themes between adjacent levels (see Figure 4) provides the most direct evidence for the "adaptive reconstruction" mechanism proposed in this study. The transmission of policy themes is not a simple linear replication but rather a dynamic process of level-by-level decomposition, specification, and reorganization.

First, the transmission process exhibits a high degree of strategic consistency. Macro-level themes from the national level, such as "Overall Framework for Development & Construction" and "Regional Collaborative Development Strategy," are clearly translated into more operational agendas at the provincial level, such as "Financial Service Innovation" and "Regional Collaborative Management." Subsequently, the transmission from the provincial to the municipal level demonstrates extremely high semantic similarity and precise alignment. Provincial policy orientations are comprehensively integrated by the municipal government into multiple specific domains, including local planning, cooperation with Macao, and the construction of the business environment, reflecting the high coherence of strategic implementation.

Second, the most crucial "adaptive reconstruction" occurs during the transmission from the municipal to the Cooperation Zone level.

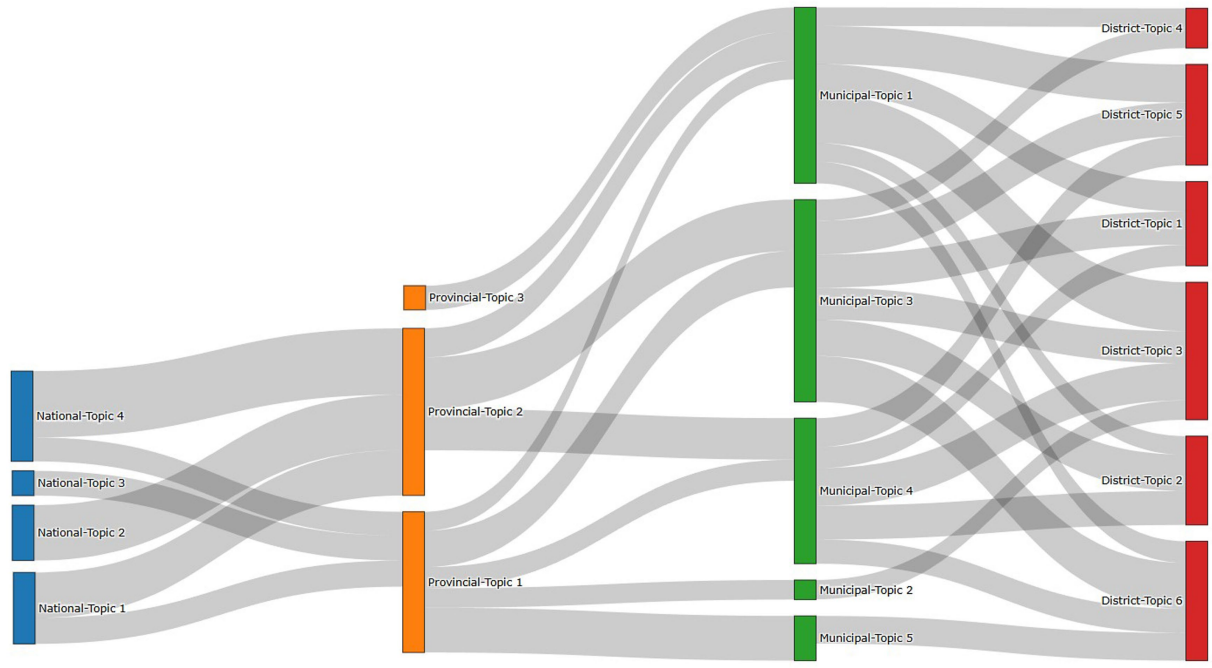

FIGURE 4
Hierarchical transmission pathways of policy themes in Hengqin. This figure illustrates the main channels and intensity of policy theme diffusion across administrative levels. The width of each flow (grey band) corresponds to the cosine similarity score between the two connected topics. The height of each node (vertical bar) represents the total sum of the similarity scores flowing into and out of that specific topic, thus visualizing its overall prominence within the transmission network.

Relatively comprehensive issues at the municipal level, such as "Comprehensive Supporting Services," are systematically decomposed and reshaped at the Cooperation Zone level into a series of more fine-grained policies closely aligned with the Zone's core missions, such as "Institutional Operational Management," "Talent Introduction & Cultivation," and "Comprehensive Supporting Services." This indicates that in the "last mile" of policy implementation, the local government acts not as a passive recipient of directives but as an active "institutional engineer." It creatively transforms the broader policy intentions of higher authorities into concrete, operational, and implementable measures that are adapted to local realities. It is precisely this bottom-up adaptive reconstruction that ensures the strategic intent of the top-level design can be effectively realized within a complex real-world environment.

4 Discussion

Through a computational analysis of the multi-level policy texts of the Hengqin Cooperation Zone, this study has revealed the multi-dimensional characteristics of its policy system. This chapter aims to situate these empirical findings within our theoretical framework for in-depth discussion. These three theoretical streams provide a complementary analytical lens for this discussion. We argue that MLG theory offers the foundational "structural scaffold" for the Hengqin system. Policy diffusion/transmission theory then helps explain the "process dynamics" that occur within this structure (i.e., how "adaptive reconstruction" happens). Finally, institutional theory reveals the "deep drivers" shaping this process, such as "critical junctures" and competing "institutional logics."

4.1 A hybrid governance architecture: rethinking multi-level governance in the Chinese context

The "functional differentiation pyramid" structure identified in this study offers a new empirical perspective for understanding MLG in China's policy pilot zones. This structure is not a simple hierarchy or network but rather a hybrid MLG configuration where the features of type I (hierarchical authority) and type II (networked, task-specific cooperation), as described by Hooghe and Marks (2003), coexist.

On the one hand, the "pyramid" shape of the governance architecture and the primary top-down pathway for policy transmission reflect the distinct characteristics of type I governance. The national level provides high-level guidance for the entire policy system by formulating macro-level frameworks and strategic principles (e.g., the "Overall Framework for Development & Construction" theme), which aligns with the type I model of hierarchical authority characterized by well-defined boundaries and general-purpose jurisdiction. The strategic intent of the central government is transmitted downward through provincial coordination and municipal planning, ensuring the core consistency of policy direction. This confirms the decisive role of central authority in shaping regional development agendas within a unitary state like China (Zhang and Zhu, 2020; Ahlers and Schubert, 2015).

On the other hand, as we delve into the pyramid's internal operations, the features of type II governance become increasingly prominent. The dramatic expansion of the policy network down the hierarchy, the specialization of community structures, and the task-oriented focus of core nodes all indicate that subnational governments are not passive

executors of commands. Instead, they form flexible, networked forms of cooperation when confronting specific and complex governance tasks. For instance, the municipal level constructs a law-based business environment centered on "arbitrators," while the Cooperation Zone level forms multiple, highly specialized policy clusters around the core mission of "In-depth Guangdong-Macao Cooperation." This governance model, which is function- and task-oriented and involves a diversity of issues, is the essence of Type II governance (Perkmann, 2003). It explains why, within a powerful hierarchical framework, the system can still maintain flexibility and professionalism at the implementation level. Therefore, the case of Hengqin demonstrates that China's regional governance is not a simple "command-and-control" system but rather a complex hybrid that combines hierarchical authority with networked, functional cooperation.

4.2 Policy transmission as adaptive reconstruction: a process-oriented perspective

A core finding of this study is that policy transmission across multiple levels is not a lossless replication of information but rather a systematic process of "adaptive reconstruction." This process encompasses the dual dimensions of strategic consistency and local adaptability, offering new insights into the concrete mechanisms of vertical transmission within policy diffusion theory.

First, the policy transmission process exhibits a high degree of strategic consistency, which aligns with the "coercion" and "learning" mechanisms in policy diffusion theory (Simmons et al., 2006; Gilardi and Wasserfallen, 2019). The analysis of thematic transmission clearly shows that the strategic intent of the national level (e.g., the "Overall Framework for Development & Construction" theme) effectively permeates down to all subnational governments and is translated into their core policy agendas. Shared core keywords constitute a "main semantic thread" that runs through the entire system, ensuring unity in fundamental objectives. This indicates that higher-level governments provide powerful guidance for the policy choices of their subordinates by setting strategic goals and evaluation frameworks.

More importantly, however, the transmission process is accompanied by profound adaptation and re-creation. This "adaptive reconstruction" is primarily achieved through two mechanisms: issue disaggregation and agenda refocusing. The community detection results from the SNA show that the relatively general policy issues from higher-level governments (e.g., "Regional Development") are systematically disaggregated at lower levels into a series of more specific, operational thematic blocks (e.g., "Industrial Finance," "Enterprise Services," "Governance Supervision"). Simultaneously, the LDA topic analysis results reveal that subnational governments refocus the diverse issues they receive in accordance with their own core missions. The most typical illustration of this is at the Cooperation Zone level, where nearly all policy themes serve the absolute core objective of "In-depth Guangdong-Macao Cooperation."

This finding challenges conventional perspectives that view policy implementation simply as a matter of transmission fidelity. Instead, we argue that the "adaptive reconstruction" undertaken by subnational governments during implementation is a necessary form of "institutional work" (Breit et al., 2016). It is not a signal of transmission failure but rather a creative "policy translation" (Sausman et al., 2016) performed by local actors to bridge the gap between the universality of higher-level policy and the particularity of the local context. It is precisely this bottom-up, agentic reconstruction that enables macro-strategies to find concrete and effective implementation pathways within complex real-world environments.

4.3 Institutional drivers of policy dynamics: critical junctures and institutional logics

The structural evolution and content dynamics of the Hengqin policy system did not emerge out of a vacuum; rather, they are profoundly driven by its unique institutional context. Institutional theory provides a critical key to understanding the underlying logic.

First, the promulgation of the 2021 Overall Plan constitutes a "critical juncture" in the institutional theory sense of the term (Mahoney, 2000; Central Committee of the Communist Party of China and State Council, 2021). As visually demonstrated in Figure 2, this event directly triggered an "explosive" growth in the volume of policies at the Cooperation Zone level. Concurrently, our time-series analysis (see Figure 3d) clearly shows that policy themes were fully activated, and the agenda rapidly shifted from early foundational development to diversified innovation highly relevant to the new mission. This dramatic shift provides powerful evidence that major, exogenous institutional changes can disrupt pre-existing development paths and open a decisive window of opportunity for reshaping policy agendas and transforming governance models. The intensive policy response by the local government following this "critical juncture" is both a reaction to the central government's demand for "experimentation under pressure" (Heilmann, 2008) and a manifestation of activated "institutional entrepreneurship" (Battilana et al., 2009) within the new institutional framework.

Second, the policy content in Hengqin is the result of the mutual competition, collision, and accommodation of multiple "institutional logics" (Thornton and Ocasio, 2008). As a special zone dedicated to aligning the rules of the mainland and Macao, its policymaking must necessarily navigate the logical conflicts arising from different institutional systems. For instance, the mainland's "state administrative logic," which emphasizes government dominance and unified planning, converges here with the "market and professional services logic" represented by Macao, which places greater emphasis on market freedom and international practices. The repeated emphasis on a "law-based business environment" (e.g., the "arbitrators" node) and the persistent focus on the convenient flow of elements such as "finance" and "cross-border" transactions that we observed in the policy texts are manifestations of these two logics accommodating each other and seeking points of convergence. In a sense, the history of policy evolution in Hengqin is a history of institutional innovation, exploring how different institutional logics can coexist and synergize within the "One Country, Two Systems" framework.

5 Conclusion

Through a systematic computational analysis of 623 policy texts from four administrative levels (2009–2024), this study has elucidated the operational dynamics of the multi-level governance system in the Guangdong-Macao In-depth Cooperation Zone in Hengqin. The research reveals that the operation of this policy system is a complex mechanism that dynamically balances strategic coherence and local

adaptation. The core argument is that this governance architecture exhibits a unique structure we term the "functional differentiation pyramid," and its core policy transmission mechanism is a process of "adaptive reconstruction." Structurally, the governance system displays clear hierarchical differentiation: the policy network size expands dramatically from the top down, while internally, a high degree of connectivity is maintained through cohesive "policy-theme communities." In terms of content, general strategic intentions from higher levels undergo significant issue decomposition and agenda refocusing during transmission. We argue that it is precisely this "institutional work," proactively undertaken by subnational governments to enhance policy fitness, that constitutes the key to the governance system's ability to simultaneously maintain strategic coherence and local flexibility.

The findings of this study offer new empirical evidence and complementary perspectives to the theories of multi-level governance, policy diffusion, and institutionalism. First, for MLG theory, the case of Hengqin reveals a hybrid MLG configuration where Type I (hierarchical authority) and Type II (networked, task-specific cooperation) coexist. This finding contributes to understanding how hierarchical control and networked cooperation can coexist within a strong central authority framework. Second, for theories of policy diffusion and transmission, by conceptualizing the transmission process as "adaptive reconstruction," this study attempts to shift the analytical focus from the "adoption/non-adoption" of policies to a discussion of policy content. Our analysis demonstrates that, in this case, vertical policy transmission is not a lossless replication of information but a process of active "policy translation" by subnational governments. This provides a new, process-oriented perspective for understanding the complexity of policy implementation and local agency. Finally, this study also provides institutional theory with a concrete case for observing institutional innovation and interaction, confirming the power of "critical junctures" to reshape policy agendas and revealing how different institutional logics compete and accommodate one another in the unique setting of a cross-border cooperation zone.

Based on these findings, this study offers several practical implications for optimizing the governance effectiveness of Hengqin and similar policy pilot zones. Policymakers should acknowledge and leverage the operational principles of the "functional differentiation pyramid" in their top-level designs. This involves further clarifying the core responsibilities of each level in strategic formulation, regional coordination, local support, and specialized execution to enhance overall governance efficiency. Simultaneously, within a framework that ensures strategic consistency, they should prudently empower local adaptive innovation, granting implementation levels sufficient autonomy in the selection of specific policy tools and implementation pathways. Corresponding evaluation and feedback mechanisms should be established to encourage beneficial localized innovations while guarding against "policy drift." For cross-border cooperation zones like Hengqin in particular, the key to success lies in the effective alignment of two systems. The institutionalized operation of "joint consultation, joint construction, joint management, and shared benefits" should be continuously deepened to transform institutional differences into drivers of innovation.

This study is, of course, subject to certain limitations. First, for SNA, our conceptual grounding of "edges" as keyword co-occurrence effectively maps thematic proximity but cannot directly infer causal or logical relationships between policy issues. Furthermore, the network metrics and community structures may be sensitive to the robustness of text preprocessing decisions, such as word segmentation and stop-word removal. For LDA, the determination of the topic number (K-value) combined statistical metrics with manual interpretation, which inevitably involves researcher subjectivity in the interpretation of results. While we have maximized the reproducibility of our analytical procedure by detailing our process and making the dataset available, these inherent limitations must be acknowledged. Second, as the research is primarily based on policy texts, future studies should incorporate in-depth interviews with policy implementers and target groups to examine the consistency between policy intent and practical outcomes. Future work could also expand the analytical framework to include non-state actors, such as enterprises and social organizations, to construct a more comprehensive picture of the governance ecosystem. Finally, the Cooperation Zone is still in a state of rapid evolution. Future research will require dynamic tracking and longitudinal comparison. Conducting systematic comparative studies would also be instrumental in distilling more generalizable theoretical insights.

Data availability statement

The datasets analyzed for this study can be found in FigShare at http://doi.org/10.6084/m9.figshare.29671793.

Author contributions

HH: Project administration, Formal analysis, Writing – review & editing, Conceptualization, Writing – original draft. YY: Supervision, Writing – review & editing, Validation. YX: Writing – review & editing, Validation, Data curation, Methodology. JC: Validation, Formal analysis, Writing – original draft. CW: Conceptualization, Writing – review & editing, Software, Methodology, Formal analysis, Writing – original draft, Visualization.

Funding

The author(s) declare that no financial support was received for the research and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The authors declare that no Gen AI was used in the creation of this manuscript.

Any alternative text (alt text) provided alongside figures in this article has been generated by Frontiers with the support of artificial intelligence and reasonable efforts have been made to ensure accuracy, including review by the authors wherever possible. If you identify any issues, please contact us.

Publisher's note

References

Ahlers, A. L., and Schubert, G. (2015). Effective policy implementation in China's local state. *Mod. China* 41, 372–405. doi: 10.1177/0097700413519563

Battilana, J., Leca, B., and Boxenbaum, E. (2009). How actors change institutions: towards a theory of institutional entrepreneurship. *Acad. Manage. Ann.* 3, 65–107. doi: 10.5465/19416520903053598

Breit, E., Andreassen, T. A., and Salomon, R. H. (2016). Modification of public policies by street-level organisations: an institutional work perspective. *J. Soc. Policy* 45, 709–728. doi: 10.1017/S0047279416000246

Central Committee of the Communist Party of China and State Council (2021) General plan for the construction of Guangdong-Macao In-depth Cooperation Zone in Hengqin. Available online at: http://www.gov.cn/zhengce/2021-09/05/content_5635547.htm (Accessed August 25, 2025).

Cheng, W., and Zhang, K. (2024). Setting 'green' boundaries for Chinese green finance: multi-level governance and regulatory stringency. *Environ. Policy Gov.* 34, 180–192. doi: 10.1002/eet.2066

DiMaggio, P. J., and Powell, W. W. (1983). The iron cage revisited: institutional isomorphism and collective rationality in organizational fields. *Am. Sociol. Rev.* 48, 147–160. doi: 10.2307/2095101

Dzisevič, R., and Šešok, D.. (2019) 'Text classification using different feature extraction approaches', in 2019 open conference of electrical, electronic and information sciences (eStream). IEEE, pp. 1–4

Gilardi, F., and Wasserfallen, F. (2019). The politics of policy diffusion. *Eur J Polit Res* 58, 1245–1256. doi: 10.1111/1475-6765.12326

Heilmann, S. (2008). Policy experimentation in China's economic rise. *Stud. Comp. Int. Dev.* 43, 1–26. doi: 10.1007/s12116-007-9014-4

Hooghe, L., and Marks, G. (2003). Unraveling the central state, but how? Types of multi-level governance. *Am. Polit. Sci. Rev.* 97, 233–243. doi: 10.1017/S0003055403000649

Klein, M., and Xhaferi, P. (2024). Observations on multi-level governance and democracy. *Aust. N. Z. J. Eur. Stud.* 16, 3–17. doi: 10.30722/anzjes.vol16.iss1/2.20008

Leydesdorff, L. (2007). Betweenness centrality as an indicator of the interdisciplinary of scientific journals. *J. Am. Soc. Inf. Sci. Technol.* 58, 1303–1319. doi: 10.1002/asi.20614

Lin, Z., Yang, Z., Lam, J. F. I., and Li, L. (2024). Guangdong-Hong Kong-Macao cooperation: historical process and driving mechanisms. *Soc. Sci.* 13:297. doi: 10.3390/socsci13060297

Mahoney, J. (2000). Path dependence in historical sociology. *Theory Soc.* 29, 507–548. doi: 10.1023/A:1007113830879

Nair, S., and Howlett, M. (2016). Meaning and power in the design and development of policy experiments. *Futures* 76, 67–74. doi: 10.1016/j.futures.2015.02.008

Perkmann, M. (2003). Cross-border regions in Europe: significance and drivers of regional cross-border co-operation. *Eur. Urban Reg. Stud.* 10, 153–171. doi: 10.1177/0969776403010002004

Piattoni, S. (2009). Multi-level governance: a historical and conceptual analysis. *J. Eur. Integr.* 31, 163–180. doi: 10.1080/07036330802642755

Röder, M., Both, A., and Hinneburg, A.. (2015) 'Exploring the space of topic coherence measures', in Proceedings of the eighth ACM international conference on web search and data mining (WSDM '15). New York: Association for Computing Machinery, pp. 399–408. doi: 10.1145/2684822.2685324

Sausman, C., Oborn, E., and Barrett, M. (2016). Policy translation through localisation: implementing national policy in the UK. *Policy Polit.* 44, 563–589. doi: 10.1332/030557315X14298807527143

Schwarz, C. (2018). Ldagibbs: a command for topic modeling in Stata using latent Dirichlet allocation. *Stata J.* 18, 101–117. doi: 10.1177/1536867x1801800107

Shim, J., Park, C., and Wilding, M. (2015). Identifying policy frames through semantic network analysis: an examination of nuclear energy policy across six countries. *Policy. Sci.* 48, 51–83. doi: 10.1007/s11077-015-9211-3

Simmons, B. A., Dobbin, F., and Garrett, G. (2006). Introduction: the international diffusion of liberalism. *Int. Organ.* 60, 781–810. doi: 10.1017/S0020818306060267

Sosa, S., Sueur, C., and Puga-Gonzalez, I. (2020). Network measures in animal social network analysis: their strengths, limits, interpretations and uses. *Methods Ecol. Evol.* 12, 10–21. doi: 10.1111/2041-210X.13366

Tang, C., Lou, S., and Ng, P. S. (2022) International trade in higher education and Macao's economic transformation, in Proceedings of the 7th international conference on distance education and learning (ICDEL 2022). New York: Association for Computing Machinery, pp. 312–318. doi: 10.1145/3543321.3543372

Teets, J. C., Hasmath, R., and Lewis, O. A. (2017). The incentive to innovate? The behavior of local policymakers in China. *J. Chin. Polit. Sci.* 22, 505–517. doi: 10.1007/s11366-017-9512-9

Thornton, P., and Ocasio, W. (2008). Institutional logics. In Institutional logics. Eds. R. Greenwood, C. Oliver, R. Suddaby and K. Sahlin (pp. 99-128). SAGE Publications Ltd. doi: 10.4135/9781849200387.n4

Wallach, H. M., Murray, I., Salakhutdinov, R., and Mimno, D. (2009) Evaluation methods for topic models, in Proceedings of the 26th annual international conference on machine learning (ICML '09). New York: Association for Computing Machinery, pp. 1105–1112.

Yao, D., Li, J., Chen, Y., Gao, Q., and Yan, W. (2022). Interactive governance between and within governmental levels and functions: a social network analysis of China's case against COVID-19. *Am. Rev. Public Adm.* 52, 191–205. doi: 10.1177/02750740211059534

Ye, Z., and Wu, W. (2024). Attracting the remote emperor's attention: local policy entrepreneurship in China's policy experimentation under hierarchy. *J. Asian Public Policy* 17, 685–703. doi: 10.1080/17516234.2022.2083930

Yi, H., and Scholz, J. T. (2016). Policy networks in complex governance subsystems: observing and comparing hyperlink, media, and partnership networks. *Policy Stud. J.* 44, 248–279. doi: 10.1111/psj.12141

Zhang, K., Li, H., Qin, L., and Wu, M.. (2011) 'Closeness centrality on BBS reply network', in 2011 international conference of information technology, computer engineering and management sciences. IEEE, pp. 80–82

Zhang, Q., Wu, Z. Y., Zhao, M., Qi, J., Huang, Y., and Zhao, H. (2017). Automatic partitioning of water distribution networks using multiscale community detection and multiobjective optimization. *J. Water Resour. Plan. Manag.* 143:04017057. doi: 10.1061/(ASCE)WR.1943-5452.0000819

Zhang, Y., and Zhu, X. (2020). The moderating role of top-down supports in horizontal innovation diffusion. *Public Adm. Rev.* 80, 209–221. doi: 10.1111/puar.13140