



Evolving Research and Innovation Discourse in Indonesia: Insights from Topic Modeling and Technological Innovation System

Shiddiq Sugiono^{1,*}, Reninta Dewi Nugraheni²

¹ Directorate of Measurement and Indicators for Research, Technology, and Innovation,
National Research and Innovation Agency (BRIN), Jakarta, Indonesia

² Research Center for Economics of Industry, Services, and Trade,
National Research and Innovation Agency (BRIN), Jakarta, Indonesia

ARTICLE INFO

Article History:

Received : 16 October 2025

Revised : 27 June 2026

Accepted : 10 July 2026

Available online : 15 July 2026

Authorship Contribution:

The main author is Shiddiq Sugiono
herein after referred to as co-author.

Keywords:

Technological Innovation System;

Topic Modeling;

Research and Innovation Discourse; and
BRIN

ABSTRACT

Indonesia's innovation system continues to face fragmentation and weak coordination, as reflected in its relatively lower position in the Global Innovation Index. Addressing this issue requires a comprehensive mapping of national innovation system, in which news media coverage may serve as a reflective arena for capturing the activities and interactions of innovation actors. This study employs the Technological Innovation System (TIS) framework based on media discourse analysis to examine the condition of Indonesia's innovation system following the establishment of the National Research and Innovation Agency (BRIN). The dataset consisted of 2,975 news articles published between 2022 and 2024 from five of Indonesia's most popular online news media. The method employed the Latent Dirichlet Allocation topic modeling, topic proportion analysis, and topic co-occurrence analysis. The findings identify 11 topics, with Industrial Policy and Economic Development emerging as the most dominant. Overall, the topic distribution aligns closely with Indonesia's national development agenda for 2020–2024. Topic proportion analysis results confirm that Indonesia's research and innovation discourse is increasingly oriented toward industrial development and environmentally sustainable energy, underscoring the urgency of mission-oriented innovation policies. Nevertheless, knowledge development and knowledge diffusion are still inadequately regarded as the central pillar within national innovation system.

* Corresponding Author.

E-mail: shid002@brin.go.id

DOI: 10.14203/STIPM.2026.435



I. INTRODUCTION

A strong innovation system constitutes a fundamental pillar of national innovation capacity. Evidence from competitiveness assessments across 126 countries indicates that the effectiveness and efficiency of innovation systems significantly influence economic growth and productivity (Bakhtiar et al., 2022). Within an effective innovation system, governments, industries, academic institutions, and civil society interact collaboratively to generate, diffuse, and apply new knowledge (Pepe et al., 2024). Such interconnected systems also enhance a country's ability to absorb and implement technologies from diverse actors, thereby supporting long-term economic sustainability (Erdin & Çağlar, 2023). Strengthening innovation systems has become a strategic imperative amid intensifying global competition.

In this regard, Indonesia's innovation system still faces structural challenges, despite continued efforts to strengthen knowledge-based competitiveness. Sectoral ego and fragmented policy priorities across governmental institutions have weakened coordination and synergy among innovation actors (Asmara & Kusumastuti, 2021), consistent with broader evidence revealing weak collaboration as a key barrier (Damuri et al., 2018). This condition has resulted in fragmented research and development (R&D) activities, limited knowledge diffusion, and suboptimal capability development. Moreover, innovation policies remain insufficiently evidence-based and poorly integrated across sectors, reducing their effectiveness in addressing science and technology-driven development needs (Mustangimah et al., 2021). The inadequacies of Indonesia's innovation system during the 2020–2024 period have hindered the effective integration of research and innovation activities in supporting industrial downstreaming initiatives (Simatupang et al., 2022). These issues underscore the need to reassess Indonesia's innovation system to enable more coherent and adaptive policy design.

In response to persistent challenges within national innovation system, Indonesia entered a new phase of research and innovation governance through the establishment of BRIN in 2021. BRIN was formed through the consolidation of multiple governmental research institutions into a single integrated body, with strategic mandates encompassing environmental quality improvement, disaster resilience, climate vulnerability reduction, and the enhancement of

national research productivity (Burhani et al., 2021). To strengthen innovation system collaboration, BRIN has initiated partnerships with higher education institutions (Suaedah et al., 2022), industry actors (Budiwati et al., 2023), and non-profit research organizations (Rahayu et al., 2025). BRIN has also expanded global research and innovation cooperation to accelerate domestic technology absorption (Dwiarto et al., 2026). Through these initiatives, BRIN is expected to function as a central institutional actor capable of addressing fragmentation and weak coordination within Indonesia's innovation system.

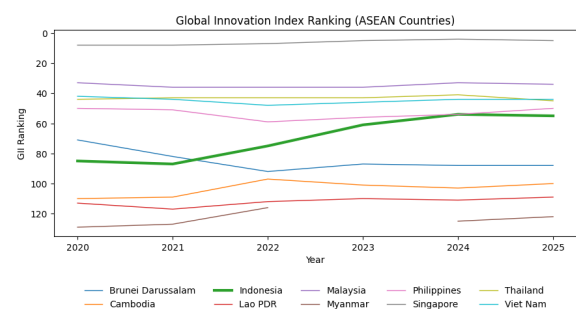


Figure 1. *Global Innovation Index (2000–2025) among ASEAN Countries*

Despite its institutional progress, Indonesia's innovation system continues to face significant challenges. As illustrated in Figure 1, although Indonesia's Global Innovation Index score improved following the establishment of BRIN, its 2024 ranking (54th) remained below those of several regional peers, such as Singapore (4th), Malaysia (33rd), Thailand (41st), and Vietnam (44th) (WIPO, 2026). This achievement is particularly conflicting given Indonesia's success in recording the highest GDP in ASEAN, reaching US\$1.36 trillion in 2024 (ASEAN, 2025). These conditions indicate a persistent disparity among Indonesia's economic capacity, competitiveness, and innovation performance.

These gaps in the downstream functions of the innovation system highlight the importance of identifying which functions are well developed and which ones remain neglected within innovation ecosystem as a foundation for strengthening innovation policy. This is because understanding innovation system dynamics would provide a framework for addressing not only technological challenges, but also broader social and economic issues linked to knowledge exchange capabilities (Casadella & Tahi, 2023; Li et al., 2023). Moreover, such comprehending also enables countries to identify bottlenecks that constrain innovation performance, thereby

supporting the formulation of more effective innovation policies (Bate et al., 2023). In the context of Indonesia, a comprehensive assessment of national innovation system, therefore, may serve as an important reference for developing more relevant and responsive policy strategies.

Current studies on Indonesia's innovation system remain fragmented and largely sector-specific, limiting a comprehensive system-level understanding. Evidence shows that innovation funding programs are still dispersed across governance levels, leading to weak alignment between local and national priorities (Putera et al., 2025). Moreover, studies examining Indonesia's innovation system through qualitative analyses of innovation policy transformation still have provided limited insights into the broader and evolving dynamics of innovation-related issues (Simatupang et al., 2022). City-level case studies, although have enhanced our understanding of actor interactions within local innovation systems, still have not provided a comprehensive depiction of the broader dynamics and characteristics of Indonesia's innovation system (Sutriadi et al., 2022). Overall, these fragmented findings highlight the need for more integrated approach that captures interaction dynamics among innovation actors.

One approach to understand innovation system dynamics is through Natural Language Processing (NLP) applied to textual documents (Wetzels et al., 2025). Prior studies have employed this method by examining scientific literature to map topics related to innovation systems and to identify temporal relationships among topics within research and innovation discourse (Rakas & Hain, 2019). Other study has employed topic modeling to examine innovation system narratives within startup ecosystems across Asia and the United States, revealing shifts in thematic emphasis between regions (Re Lee et al., 2023). However, these prior studies in general did not explicitly anchor topic development within a structured innovation system framework. Hence, this study aims to address this gap by aligning topic identification with a defined innovation system framework to enable more structured interpretation.

This study specifically examines the condition of Indonesia's innovation system using national-level textual data, enabling the identification of key thematic areas and issues requiring policy intervention. The analysis covers the 2022–2024 period to capture BRIN's post-establishment phase and its role in consolidating research and

innovation governance at the national level. This study seeks to answer the following questions:

1. What innovation system topics are reflected in Indonesia's national research and innovation textual data, and which topics are most dominant during the 2022–2024 period?
2. Which innovation system topics exhibit significant changes in proportion within Indonesia's research and innovation discourse during the 2022–2024 period?
3. What are the patterns of topic co-occurrence in representing Indonesia's innovation system during the 2022–2024 period?

II. ANALYTICAL FRAMEWORK

The Technological Innovation System (TIS) functional framework proposed by Hekkert et al. (2007) is employed in this study to operationalize Indonesia's innovation system activities. The framework consists of seven core functions that serve as analytical building blocks for identifying whether innovation activities are operating effectively and sustainably. Table 1 provides a brief description of TIS's functions. Actors within innovation system engage in a range of activities that can be mapped onto these seven functions, allowing researchers to capture the interaction structure of innovation system dynamics.

Table 1. *TIS's Functions*

Activity	Definition
Entrepreneurial Activities	Entrepreneurial activities that transform knowledge and market opportunities into concrete actions through experimentation and innovation.
Knowledge Development	Knowledge development through research and development (R&D) activities as a foundational basis for the innovation process.
Knowledge Diffusion	Knowledge diffusion among actors through interaction networks that facilitate information exchange and learning.
Guidance of the Search	Direction of research and investment toward specific technologies through the articulation of goals and expectations by key actors.
Market Formation	The formation of markets for new technologies through regulation, tax incentives, or the creation of protected market niches.
Resource Mobilization	Mobilization of financial resources and human capital required to support all innovation activities.
Creation of Legitimacy	The creation of legitimacy and social acceptance for new technologies through advocacy and coalition-building to overcome resistance.

The TIS framework, although is not a recent conceptual development, continues to be widely applied in recent studies to examine innovation systems, both in general and specific thematic contexts. Several studies have used primary data concerning technological innovation processes to

map TIS's functions as well as to identify enablers and barriers arising from interactions among these functions (Holzer et al., 2023; Lim et al., 2026; Temmes et al., 2021; Tigabu et al., 2015). Other studies have applied qualitative analysis of policy documents through the TIS lens to identify innovation-related activities within the document texts (Huttunen et al., 2025; Schepelmann et al., 2021). However, there is no study to date that applies the TIS framework to systematically map innovation activities in the specific context of Indonesia. This study, therefore, serves as an initial exploratory effort toward a more structured thematic analysis of Indonesia's innovation system.

To operationalize the TIS framework in the context of Indonesia, this study adopts an approach based on the analysis of national news articles. News media function as an arena that reports innovation actors, social actors, and their interactions (Belair-Gagnon & Steinke, 2020). In covering innovation-related developments, media narratives typically reflect economic implications, political drivers, and governance dynamics within a country (Nguyen & Hekman, 2024). Given news media's role in capturing both actors and innovation activities in this sense, this study leverages news articles to identify and analyze Indonesia's innovation system activities.

BRIN, as a national institution, constructs discourse through the framing of "research and

innovation," positioning both element as inseparable strategic pillars in knowledge-based development (Bovandra & Riewanto, 2024). The discourse emphasizes economic growth and productivity, thereby encouraging actors to invest in infrastructure, ideas, and innovative outcomes (Bagattolli & Brandão, 2021). Through the institutionalization of the "research and innovation" narratives, media coverage centered on these terms is utilized as an analytical entry point to examine the existing condition of Indonesia's innovation system.

Media coverage plays a key role in constructing discourse that shapes issue salience, making it essential to understand how particular issues are prioritized. Issue salience refers to public perceptions regarding the importance, relevance, and urgency of specific issues relative to other issues (Oppermann & Viehriq, 2009). Through its agenda-setting function, media coverage can actively construct issue salience by framing certain topics in certain ways that elevate their prominence over competing issues (Douglas-Durham et al., 2025). Media coverage also reflects issues that are considered central within society, thereby serving as a proxy for public perceptions of significance and urgency (Rauh & Parizek, 2024). Understanding patterns of issue salience, therefore, is critical for policymakers to ensure that policy decisions are aligned with public concerns and priorities.

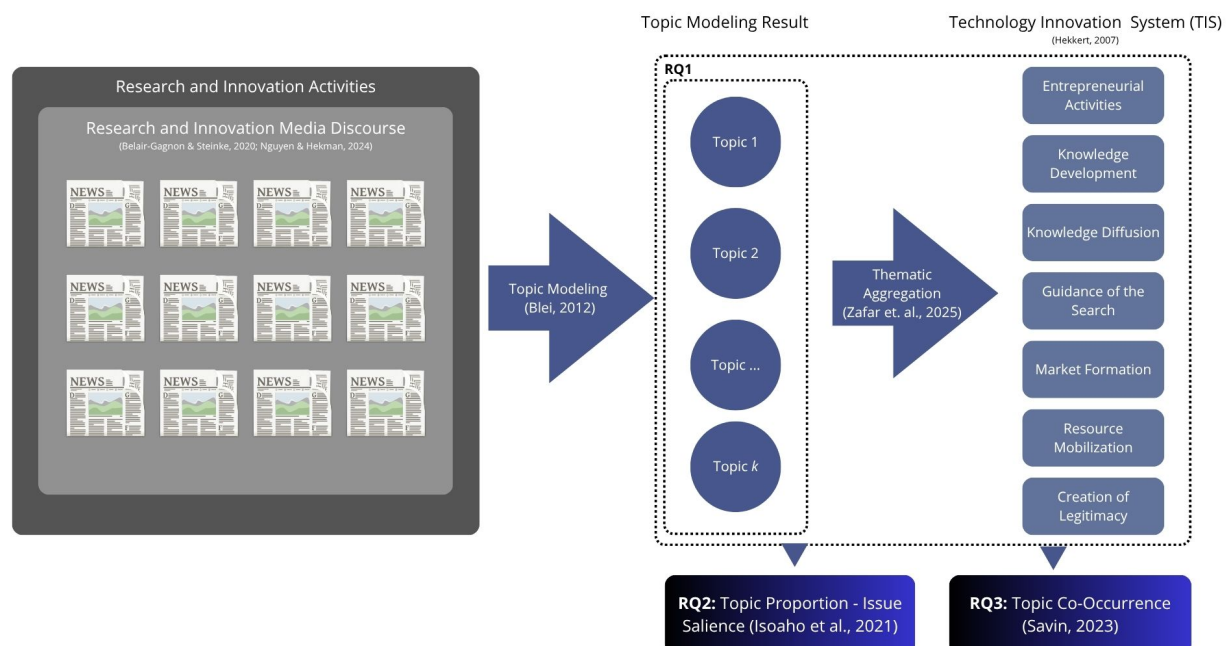


Figure 2. Analytical Framework

Figure 2 presents this study's analytical framework. It conceptualizes national media coverage on research and innovation discourse as an interaction arena among innovation actors, while simultaneously reflecting their activities. Topics extracted from national news articles are mapped onto seven TIS's functions to identify which functions are well developed and which ones remain weak within Indonesia's innovation ecosystem. Issue salience, i.e., the level of importance attached to these topics, is used to assess which issues should be prioritized by innovation system stakeholders to facilitate more responsive and context-sensitive policymaking. Issue salience is selected here as a determinant, since it—alongside scientific evidences—is also considered a complementary basis for policy formulation (Bromley-Trujillo & Poe, 2020).

III. METHODOLOGY

Data used in this study comprised online news articles published between 2022 and 2024. The data were drawn from detik.com, Kompas.com, tribunnews.com, cnnindonesia.com, and tvonenews.com, all of which were recorded in 2024 as the five most popular and trusted online news media among Indonesian public (Newman et al., 2024). To establish a clear boundary regarding research and innovation discourse, only articles indexed with the keywords “riset” (research) and “inovasi” (innovation), published between January 1, 2022, and December 31, 2024, were included as research data. This period was selected as it represents the effective years of BRIN's operation following its establishment in 2021.

The data collected were processed via web scraping techniques using the Python programming language, employing the BeautifulSoup4, Selenium, and WebDriver libraries to parse the structure and content of HTML. The scraping process was conducted by sequentially extracting news content from search indexes containing the keywords “riset” (research) and “inovasi” (innovation). Data were retrieved in February 2025, covering several variables, such as article titles, content, URLs, and publication dates.

In terms of ethical considerations, the scraping process was conducted responsibly by limiting request frequency to avoid server overload, accessing only publicly available content without bypassing any access restrictions, while ensuring that the collected data were used solely for academic and non-commercial purposes. No personally identifiable information was collected throughout the data retrieval process. Additionally, the collected data were not

reproduced or redistributed in any form and the entire data collection procedure was documented systematically to ensure transparency and replicability in accordance with academic research ethics standards.

Prior to analysis, the articles collected underwent seven steps of preprocessing to ensure data quality and analytical readiness: (1) duplicate articles were identified and removed based on URL and content similarity; (2) photo galleries were filtered out and excluded due to their limited textual content; (3) articles without the keywords “riset” or “inovasi” within the body texts were filtered out; (4) the texts were cleaned by removing punctuations, numbers, HTML tags, and special characters; (5) tokenization was used to split the texts into individual word units; (6) stopword removal was performed using stopword dictionaries from the Sastrawi Python library and genediazjr (2016), ensuring that only substantive and meaningful words were retained; and (7) stemming was conducted using the Sastrawi stemmer to reduce words to their base forms, thereby minimizing lexical variation across articles. These seven steps, conducted using Python, also included only terms appearing at least three times across articles, resulting in a final dataset comprising 2,975 news articles.

Next, the dataset was analyzed via topic modeling using the Probabilistic Latent Dirichlet Allocation (LDA) technique (Blei, 2012). The LDA topic modeling assumes that each article represents a mixture of several topics and each topic represents a probabilistic distribution of specific words. This approach enables the systematic identification of hidden patterns within the body texts, thereby providing a more comprehensive understanding of discourse structures. LDA operates by analyzing the term–article matrix, where each row represents an article and each column represents a term. Each article is treated as a mixture of topics and each topic is treated as a distribution of words (Albalawi et al., 2020). To determine the optimal number of topic, this study employed two evaluation metrics: perplexity and coherence (Yusof & Saeed, 2024). Perplexity scores were used for varying number of topic and visualized through a curve, where the point with the lowest average perplexity score indicated a statistically preferable number of topic. Meanwhile, coherence scores were used to assess the extent to which the generated topics could be meaningfully interpreted; the higher the coherence score, the higher the interpretability.

Topic mapping step onto TIS's functions employed the Thematic Aggregation method to

qualitatively synthesize extracted topics into higher-order themes (Zafar et al., 2025). The assignment of topics onto seven TIS's functions was conducted through in-depth discussion and consensus among all authors. The absence of an inter-rater coding procedure was acknowledged as this step's limitation.

To operationalize issue salience in news media coverage, this study used topic proportion outputs (Isoaho et al., 2021), defined as the probabilistic distribution of topics within articles over time generated by topic modeling. Statistical significance of temporal differences over years in topic proportions was assessed using the Kruskal–Wallis test, while specific years with significant differences were identified using the post-hoc Dunn test (Wu & Liang, 2025).

Lastly, a network graph was constructed to visualize the relationships among topics generated by the LDA model. To highlight significant

connections, the approach suggested by Savin (2023) was adopted by constructing a co-occurrence matrix that captures the joint appearances of active topics across articles. Only edges representing the top 5% of co-occurrence weights (95th percentile) were retained, ensuring that only the strongest associations were visualized in the network graph. Active topics were defined as those with a probability or proportion of ≥ 0.1 within an article. This approach enabled the visualization of the most closely related topic clusters while distinguishing the structural relationships among topics.

IV. RESULTS

Prior to conducting topic mapping, this study determined the optimal number of topic to be selected. This step is essential to ensure efficiency in topic construction and to minimize overlap among the resulting topics.

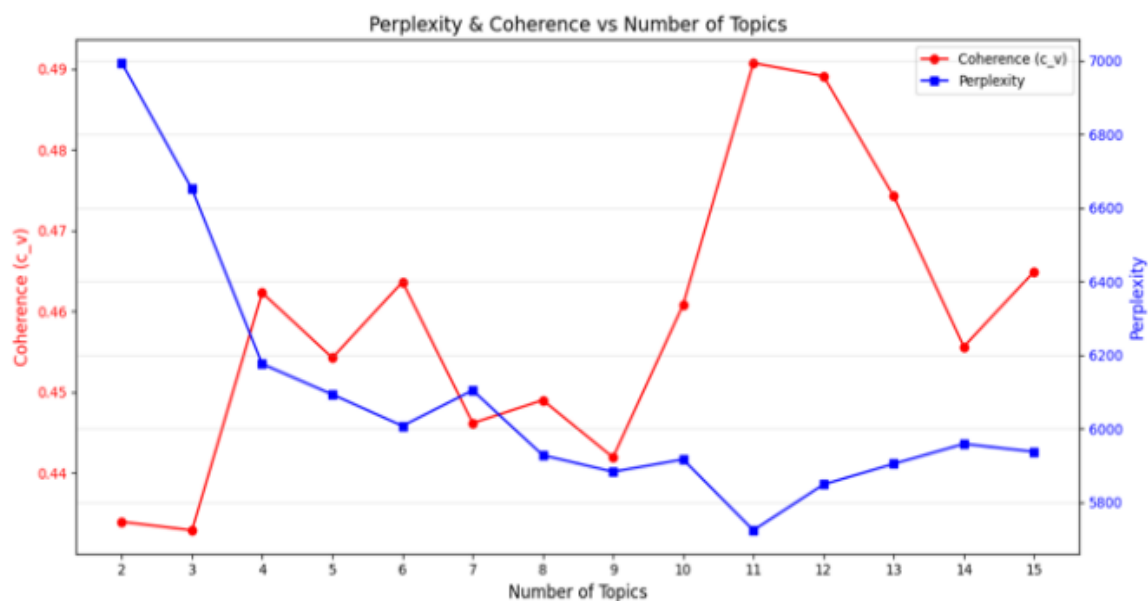


Figure 3. Perplexity and Coherence Scores Indicating Optimal Number of Topic

Coherence and perplexity scores were used to determine the optimal number of topic in mapping Indonesia's research and innovation discourse. As shown in Figure 3, both the highest coherence score (5723.01) and the lowest perplexity score (0.4907) were obtained at the topic number of 11. Therefore, this study selected 11 topics to be examined. This number also provides a manageable and interpretable topic structure without excessive fragmentation.

A. Topic Mapping onto TIS's Functions

The topic modeling results of national innovation-related news identified 11 topics distributed across

seven TIS's functions. Overall, the distribution is highly uneven, with Industrial Policy & Economic Development topic representing the largest share (26.92%), while Consumer Technology Product Innovation topic accounts for the smallest proportion (0.44%). At the functional level, Guidance of the Search and Entrepreneurial Activities functions dominate media coverage, jointly comprising 43.64% of the dataset. In contrast, Knowledge Diffusion function is minimally represented, covering only 2.52% of the dataset. Table 2 presents a detailed description of the 11 topics and their mapping results onto TIS's functions.

Table 2. Description of Topics and Their Distribution within TIS's Functions

No.	Topic Label (Number – Percentage)	Representative Word	Topic Description	TIS's Function
1.	Entrepreneurship & Digital Market (252 – 8.47%)	sold ["laku"] product ["produk"] market ["pasar"] business ["usaha"] enterprise ["bisnis"] innovation ["inovasi"] people ["orang"] service ["layan"] ownership ["milik"] data ["data"]	Business actors leverage digital innovation to develop new products and services, thereby expanding market reach.	Entrepreneurial Activities
2.	Education Innovation & Human Capital Development (493 – 16.57%)	innovation ["inovasi"] student ["mahasiswa"] educate ["didik"] team ["tim"] technology ["teknologi"] teach ["ajar"] develop ["kembang"] university ["universitas"] program ["program"] teacher ["guru"]	Universities and educational institutions play an active role in developing innovative human capital through technology-based learning programs.	Resource Mobilization
3.	Green Production & Waste Management Innovation (315 – 10.59%)	material ["bahan"] water ["air"] environment ["lingkung"] output ["hasil"] waste ["limbah"] product ["produk"] garbage ["sampah"] production ["produksi"] benefit ["manfaat"] process ["proses"]	Production activities are developed using environmentally friendly approaches to reduce waste and improve resource-use efficiency.	Knowledge Development
4.	Consumer Technology Product Innovation (13 – 0.44%)	AI ["ai"] Oppo ["oppo"] culture ["budaya"] UNJ ["unj"] camera ["kamera"] Reno ["reno"] present ["hadir"] king ["raja"] museum ["museum"] feature ["fitur"]	The launch of consumer technologies, such as smartphones and artificial intelligence, promotes innovation adoption within society in a local cultural context.	Market Formation
5.	Energy & Natural Resource Regulation Policy (18 – 0.61%)	nickel ["nikel"] mining ["tambang"] nuclear ["nuklir"] mineral ["mineral"] parliament ["dpr"] law ["undang"] Megawati ["megawati"] smelter ["smelter"] commission ["komisi"] chairman ["ketua"]	Regulatory and legislative processes are mobilized to govern the management of strategic natural resources in support of national energy sovereignty.	Guidance of the Search
6.	Regional Innovation & Community Development (417 – 14.02%)	build ["bangun"] city ["kota"] village ["desa"] community ["masyarakat"] region ["daerah"] sold ["laku"] government ["perintah"] Jakarta ["jakarta"] innovation ["inovasi"] road ["jalan"]	The implementation of innovation at the subnational level supports urban and rural development as well as improvements in public service quality.	Creation of Legitimacy
7.	Health Research & Medical Innovation (108 – 3.63%)	health ["sehat"] people ["orang"] sick ["sakit"] research ["eliti"] discover ["temu"] medicine ["obat"] human ["manusia"] scientist ["ilmuwan"] path ["jalan"] life ["hidup"]	Scientists and research institutions produce findings in health and biomedicine to strengthen national medical innovation capacity.	Knowledge Development
8.	Research Institution & Scientific Publication (75 – 2.52%)	research ["riset"] study ["teliti"] BRIN ["brin"] university ["universitas"] output ["hasil"] write ["tulis"] scientific ["ilmiah"] Indonesia ["indonesia"] field ["bidang"] of ["of"]	BRIN and universities promote scientific knowledge production through collaborative research and the dissemination of research outputs to the public.	Knowledge Diffusion
9.	Industrial Policy & Economic Development (801 – 26.92%)	Indonesia ["indonesia"] business ["usaha"] industry ["industri"] work ["kerja"] economy ["ekonomi"] level ["tingkat"] develop ["kembang"] country ["negara"] build ["bangun"] support ["dukung"]	National industrial policy is directed toward strengthening innovation-based economic competitiveness and promoting sustainable growth.	Guidance of the Search
10.	Food Innovation & Agricultural Products (37 – 1.24%)	farmer ["tani"] food ["pangan"] plant ["tanam"] eat ["makan"] fruit ["buah"] coffee ["kopi"] product ["produk"] skin ["kulit"] rice ["padi"] halal ["halal"]	Farmers and food industry actors develop innovative agricultural products to address diverse and value-added food demands.	Entrepreneurial Activities
11.	Energy Transition & Green Innovation (446 – 14.99%)	energy ["energi"] electricity ["listrik"] carbon ["karbon"] emission ["emisi"] Indonesia ["indonesia"] vehicle ["kendara"] develop ["kembang"] rise ["bangkit"] solar power ["pls"] power ["tenaga"]	The development of renewable energy and electric vehicles is promoted as part of Indonesia's transition toward a low-carbon energy system.	Market Formation

Entrepreneurial Activities function is represented by two topics: Entrepreneurship & Digital Market (8.47%) and Food Innovation & Agricultural Products (1.24%). These topics reflect entrepreneurial activities operating across two distinct sectors: digital economy and agriculture. Although their proportions are relatively moderate, their presence in media coverage indicates that entrepreneurial activities are increasingly gaining public attention as a driver in shaping national innovation system.

Knowledge Development function is represented by two topics: Green Production & Waste Management Innovation (10.59%) and Health Research & Medical Innovation (3.63%). The dominance of green production topic suggests that research and innovation discourse in national media coverage is mainly associated with environmental sustainability and ecological concerns rather than with other domains. Meanwhile, medical innovation discourse reflects growing public attention to health-related researches, particularly in the context of post-pandemic situations.

Knowledge Diffusion function is represented by one topic, namely Research Institution & Scientific Publication (2.52%), which specifically relates to institutional activities involving BRIN and scientific publication outputs. The relatively low proportion of this function in national media coverage indicates that knowledge dissemination mechanisms across actors, including research collaboration and technology transfer, still have not received substantial public attention, despite their critical role in strengthening innovation system connectivity.

Guidance of the Search is the most dominant function across the dataset, represented by two topics: Industrial Policy & Economic Development (26.92%) and Energy & Natural Resource Regulation Policy (0.61%). The strong dominance of industrial policy discourse indicates that public narratives concerning Indonesia's innovation activities are largely concentrated on macroeconomic policy agendas and national industrial development directions.

Market Formation function is represented by two topics: Energy Transition & Green Innovation (14.99%) and Consumer Technology Product Innovation (0.44%). The prevalence of energy transition topic suggests that new technology market formation in national media coverage is primarily associated with renewable energy and electric vehicle agendas. In contrast, consumer

technology product innovation receives minimal coverage, indicating limited media attention to market dynamics in consumer-oriented innovation sectors.

Resource Mobilization function is represented by one topic, namely Education Innovation & Human Capital Development (16.57%), which constitutes the second-largest proportion across the dataset. This high share reflects substantial media attention to human capital development through higher education institutions as a foundational element for strengthening national innovation capacity.

Lastly, Creation of Legitimacy function is represented by one topic: Regional Innovation & Community Development (14.02%). Its substantial proportion indicates that media coverage of innovation at the subnational level receives significant attention, reflecting efforts to foster social acceptance of innovation through its application in the context of community and regional development.

B. Temporal Analysis of Topic Proportion

As seen in Table 3, the significance test results of research and innovation discourse in online news media coverage show statistically significant shifts in topic proportion during the 2022–2024 period. Energy Transition & Green Innovation and Industrial Policy & Economic Development topics show significant increase during this period. In contrast, Education Innovation & Human Capital Development, Health Research & Medical Innovation, and Entrepreneurship & Digital Market topics exhibit significant decline in their proportions. The remaining topics display fluctuating patterns across the observed period.

In Resource Mobilization and Knowledge Development functions, media coverage shows a significantly declining trend in three topics: Education Innovation & Human Capital Development, Green Production & Waste Management Innovation, and Health Research & Medical Innovation. These decreases suggest a reduced media emphasis on foundational issues, such as education, human capital, and health research, as central themes. This shift can be interpreted as a reframing from a foundation-building phase toward a utilization of innovation outcomes phase, where capacity-related issues remain present but are no longer dominant within public discourse.

Conversely, Market Formation and Guidance of the Search functions show significant increase in two topics: Energy Transition & Green Innovation and Industrial Policy & Economic Development.

These findings reflects growing media attention to the role of policy in steering innovation, particularly in the context of energy transition and industrial-based economic development. The increase indicates alignment between media narratives and national strategic priorities, where downstream industrialization, green transition, and decarbonization agendas become increasingly prominent within public discourse (Ministry of National Development Planning/National Development Planning Agency, 2019).

Meanwhile, the observed dynamics in Entrepreneurial Activities and Creation of

Legitimacy functions indicate a shift in focus from digital innovation toward more regionally and socially embedded approaches. The decline in Entrepreneurship & Digital Market topic suggests reduced media intensity on digital economy narratives as an emerging issue, potentially reflecting its transition into a more mature stage. In contrast, the significant increase in Regional Innovation & Community Development topic indicates that media coverage is increasingly highlighting more inclusive and context-specific innovation discourse at the local level.

Table 3. *Significance Test Results concerning Shifts in Topic Proportion during the 2022–2024 Period*

TIS's Function	Topic Labels	Proportion in 2022 (%)	Proportion in 2023 (%)	Proportion in 2024 (%)	Kruskal-Wallis Test	Dunn Test 2022–2023	Dunn Test 2023–2024
Resource Mobilization	Education Innovation & Human Capital Development	25.80	14.97	9.91	0.000*	0.000*	0.000*
Market Formation	Consumer Technology Product Innovation	1.63	0.77	0.78	0,453	1,000	0,767
Market Formation	Energy Transition & Green Innovation	4.74	13.49	16.89	0.000*	0.000*	0.015*
Knowledge Diffusion	Research Institution & Scientific Publication	5.87	3.71	4.15	0.000*	0.000*	0.020*
Knowledge Development	Green Production & Waste Management Innovation	10.83	10.67	7.96	0.022*	1.000	0.062
Knowledge Development	Health Research & Medical Innovation	6.88	4.12	3.63	0.000*	0.001*	0.513
Guidance of the Search	Energy & Natural Resource Regulation Policy	1.27	1.44	1.17	0.275	0.487	1.000
Guidance of the Search	Industrial Policy & Economic Development	15.09	25.50	29.88	0.000*	0.000*	0.000*
Entrepreneurial Activities	Entrepreneurship & Digital Market	13.02	9.30	9.98	0.000*	0.000*	0.109
Entrepreneurial Activities	Food Innovation & Agricultural Products	3.22	1.87	1.67	0.280	0.574	1.000
Creation of Legitimacy	Regional Innovation & Community Development	11.65	14.15	13.98	0.010*	0.021*	1.000

C. Topic Co-Occurrence Network

Topic co-occurrence network, constructed from the co-occurrence matrix using an activity threshold of ≥ 0.1 and retaining only the top 5% strongest links, reveals a selective and highly focused discourse structure. This approach

ensures that the observed relationships reflect the most dominant narrative associations—rather than incidental co-occurrences—within research and innovation discourse in news media coverage. Overall, the network exhibits a centralized pattern with a single dominant hub and several isolated

topics, suggesting a clear distinction between an integrated core narrative and peripheral, stand-alone narratives within TIS's functional structure.

Figure 4 presents the resulting topic co-occurrence network.

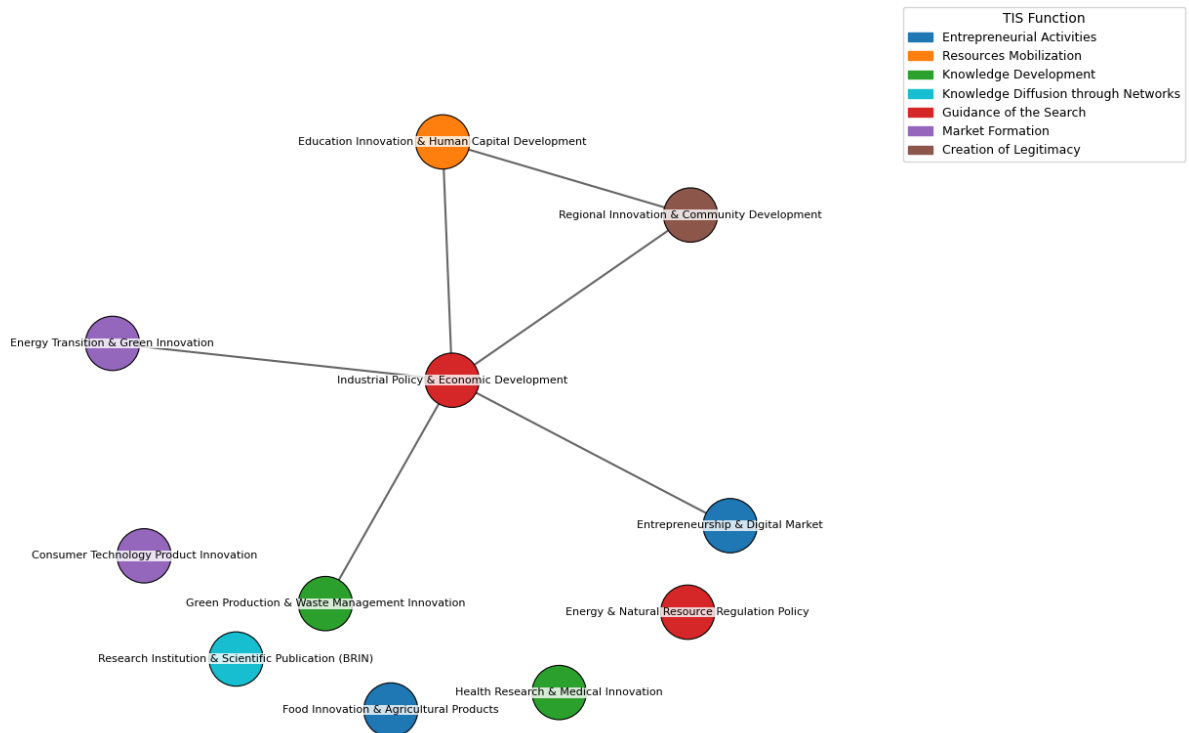


Figure 4. Topic Co-Occurrence Network

The dominance of Industrial Policy & Economic Development topic as the central node indicates a strong Guidance of the Search function, where innovation direction within media narratives is heavily shaped by policy and development strategies. Its strong connections with Energy Transition & Green Innovation and Entrepreneurship & Digital Market topics also reflect close interaction with Market Formation function, while its linkage to Education Innovation & Human Capital Development topic indicates association with Resource Mobilization function. This finding suggests that, within media narratives, policy serves not only to provide direction, but also to act as an integrative mechanism linking markets, resources, and technological trajectories, thereby forming a more cohesive innovation system narratives.

In contrast, the sub-network between Regional Innovation & Community Development and Education Innovation & Human Capital Development topics reflects the combined influence of Creation of Legitimacy and Resource Mobilization functions, emphasizing the role of social acceptance and capacity strengthening in local-level innovation implementation. Meanwhile, isolated topics, such as Health Research & Medical Innovation, Food Innovation

& Agricultural Products, and Research Institution & Scientific Publication, indicate weak integration within Knowledge Development and Knowledge Diffusion functions, as these topics do not appear within the strongest co-occurrence relationships. This suggests that, although Knowledge Production and Knowledge Diffusion functions are present, they remain inadequately embedded within the dominant industrial-oriented innovation discourse.

V. DISCUSSION

The LDA topic modeling employed in this study reveals dynamic shifts in issue salience within research and innovation discourse in online news media coverage. The identified topics are closely aligned with Indonesia's national development agenda as outlined in the National Medium-Term Development Plan (RPJMN) 2020–2024, which emphasizes economic resilience, environmental sustainability, human capital development, and regional development (Ministry of National Development Planning/National Development Planning Agency, 2019). The highly increasing salience of Energy Transition & Green Innovation topic can be attributed to Indonesian government's strategic focus on developing an enabling ecosystem for electric vehicles through policy

interventions and global market expansion efforts (Ariyani et al., 2025). Conversely, the low and decreasing salience of Food Innovation & Agricultural Products topic is consistent with prior studies on agricultural innovation systems highlighting persistent gaps in policy support and resource allocation in Indonesia's several regions (Valerio et al., 2022). Overall, the observed dynamics of issue salience provide a structured representation of Indonesia's innovation system and can serve as a reference for understanding the prevailing public concerns and policy priorities.

The analysis results of topic interactions indicate that Guidance of the Search function serves as the central node within TIS's functional structure, closely connected to Resource Mobilization, Market Formation, Knowledge Development, and Entrepreneurial Activities functions. A similar pattern has been observed in the Austrian wood and plastics innovation systems, where Guidance of the Search function serves as a core function driving entrepreneurial experimentation, resource mobilization, and ultimately market formation (Holzer et al., 2023). Similar findings were also reported in Rwanda's innovation system, where this function plays a central role in stimulating resource mobilization and entrepreneurial activities (Tigabu et al., 2015). Other studies further emphasized that Guidance of the Search function creates both pressure for actors to engage within innovation and opportunity systems for the public sector to shape policy, regulation, and strategic direction (Huttunen et al., 2025). Guided by Industrial Policy & Economic Development topic as the dominant discourse, innovation policy has increasingly focused on fostering stronger interactions between innovation actors and industrial sector to enhance the competitiveness of Indonesia's industrial landscape (Ariyani et al., 2025; Sutriadi et al., 2022).

On the other hand, the findings also highlight that Knowledge Development and Knowledge Diffusion functions exhibit limited interaction with other TIS's functions. This appears to contradict several prior studies revealing that Knowledge Development function typically serves as a starting point for Guidance of the Search, Entrepreneurial Activities, and Market Formation functions (Holzer et al., 2023; Temmes et al., 2021). For instance, a study in Finland revealed Knowledge Development and Knowledge Diffusion functions as central pillars within clean energy innovation system (Temmes et al., 2021). Likewise, in the context of European biodiversity conservation, knowledge-related functions play a critical role as the foundation for

action, policy programs, and technological adoption (Huttunen et al., 2025). Given Indonesia's situation, these conflicting findings are actually consistent with prior mapping of the country's innovation system, which identifies weak coordination between knowledge-producing actors and other system stakeholders (Damuri et al., 2018). The ineffective integration of innovation activities across actors within Indonesia's innovation system has impeded the effectiveness of national industrial downstreaming agenda (Simatupang et al., 2022). This drawback suggests that knowledge diffusion among innovation actors needs to be embedded in reliable public policies and institutionalized within dedicated innovation-supporting ecosystem (Sutriadi et al., 2022). In this sense, strengthening the role of research institutions and higher education systems is essential to ensure that innovation trajectories are more strongly grounded in knowledge generation and diffusion.

VI. CONCLUSION

This study, through analysis of online news articles, identifies the distribution, temporal dynamics, and interactions of 11 topics within Indonesia's research and innovation discourse during the 2022–2024 period. Overall, the nation's research and innovation discourse shows a strong orientation toward technological development, research, and innovation within the corridor of environmentally sustainable industrial transformation, reflecting increasing alignment with global sustainability agendas and national energy transition. This trend suggests that Indonesian government should strengthen mission-oriented innovation policies that explicitly direct research and technological development toward green industrial transformation. Meanwhile, the central role of industrial actors within research and innovation discourse indicates their growing recognition as key drivers of Indonesia's innovation activities.

However, the findings also reveal structural imbalances within national innovation system. Knowledge Development and Knowledge Diffusion functions are not fully integrated into the dominant discourse, which remains primarily focused on policy direction and market formation. This fragmentation may reflect persistent challenges in translating scientific knowledge into industrial and economic outcomes, potentially constraining Indonesia's global competitiveness. In response, national research institutions and higher education systems need to strengthen their role as knowledge intermediaries by fostering stronger linkages among government, industry,

and society. This is essential to ensure that knowledge creation, dissemination, and utilization are more effectively integrated within national innovation system.

For this reason, future studies are recommended to complement this media-based analysis with in-depth policy document analysis and interviews with key innovation stakeholders to more comprehensively map TIS's functions in Indonesia and to capture other dynamics that may not be fully reflected in public discourse. In addition, more aimed analyses also should be conducted to examine specific technological innovation domains for generating more context-sensitive and policy-relevant recommendations.

REFERENCES

- Albalawi, R., Yeap, T. H., & benyoucef, m. (2020). Using topic modeling methods for short-text data: A comparative analysis. *Frontiers in Artificial Intelligence*, 3. <https://doi.org/10.3389/frai.2020.00042>
- Ariyani, L., Aminullah, E., Hermawati, W., Febrianda, R., Rosadi, A. H. Y., & Dinaseviani, A. (2025). The global innovation system view for electric vehicles in Indonesia: Facilitating the transition to electric mobility in society. *Sustainable Futures*, 9. <https://doi.org/10.1016/j.sfr.2025.100741>
- ASEAN. (2025). ASEAN key figures 2025. <https://asean.org/serial/asean-key-figures-2025/>
- Asmara, A. Y., & Kusumastuti, R. (2021). Innovation policy implementation in Indonesia: Perspective of Triple Helix. *STI Policy and Management Journal*, 6(1). <https://doi.org/10.14203/stipm.2021.290>
- Bagattolli, C., & Brandão, T. (2021). Contesting the mainstream narrative? A conceptual discussion on the politics of science, technology, and innovation from the periphery. *Journal of Scientometric Research*, 10 (1), S5–S20. <https://doi.org/10.5530/JSCIRES.10.1S.18>
- Bakhtiar, A., Ghazinoory, S. S., Aslani, A., & Mafi, V. (2022). Efficiency-effectiveness assessment of national innovation systems: Comparative analysis. *Journal of Science and Technology Policy Management*, 13(3), 625–651. <https://doi.org/10.1108/JSTPM-03-2021-0044>
- Bate, A. F., Wachira, E. W., & Danka, S. (2023). The determinants of innovation performance: An income-based cross-country comparative analysis using the Global Innovation Index (GII). *Journal of Innovation and Entrepreneurship*, 12(1). <https://doi.org/10.1186/s13731-023-00283-2>
- Belair-Gagnon, V., & Steinke, A. J. (2020). Capturing digital news innovation research in organizations, 1990–2018. *Journalism Studies*, 1724–1743. <https://doi.org/10.1080/1461670X.2020.1789496>
- Blei, D. M. (2012). Probabilistic topic models. *Communications of the ACM*, 55(4), 77–84. <https://doi.org/10.1145/2133806.2133826>
- Bovandra, M., & Riewanto, A. (2024). Pengarusutamaan Pancasila dalam perencanaan pembangunan nasional berbasis riset dan inovasi. *Pancasila: Jurnal Keindonesiaan*, 4(1), 105–118. <https://doi.org/10.52738/pjk.v4i1.445>
- Bromley-Trujillo, R., & Poe, J. (2020). The importance of salience: Public opinion and state policy action on climate change. *Journal of Public Policy*, 40(2), 280–304. <https://doi.org/10.1017/S0143814X18000375>
- Budiwati, S. V., Sundari, S., Hudaya, D. S., & Niken, N. (2023). Strategi penguatan tata kelola pemanfaatan riset dan inovasi (Studi kasus: kerjasama pemanfaatan riset dan inovasi BRIN dengan industri). *J-MACC - Journal of Management and Accounting*, 6(1). <https://doi.org/10.52166/j-macc.v6i1.4146>
- Burhani, A. Najib., Mulyani, Lilis., & Pamungkas, Cahyo. (2021). The National Research and Innovation Agency (BRIN): A new arrangement for research in Indonesia. ISEAS, Yusof Ishak Institute. <https://www.iseas.edu.sg/articles-commentaries/trends-in-southeast-asia/the-national-research-and-innovation-agency-brin-a-new-arrangement-for-research-in-indonesia-by-ahmad-najib-burhani-lilis-mulyani-and-cahyo-pamungkas/>
- Casadella, V., & Tah, S. (2023). National innovation systems in low-income and middle-income countries: Re-evaluation of indicators and lessons for a learning economy in Senegal. *Journal of the Knowledge Economy*, 14(3), 2107–2137. <https://doi.org/10.1007/s13132-022-00945-8>
- Damuri, Y. R., Aswicahyono, H., & Christian, D. (2018). Innovation policy in Indonesia. M.

- Ambashi, Innovation Policy in ASEAN, 96–127.
<https://ideas.repec.org/h/era/chaptr/2018-innovation-policy-in-asean-4.html>
- Douglas-Durham, E., Tan, A. S. L., Emmons, K. M., & Viswanath, K. (2025). The relationship between news coverage of COVID-19 misinformation and online search behavior. *Health Communication*, 40(7), 1280–1288.
<https://doi.org/10.1080/10410236.2024.2395155>
- Dwiarto, R., Nurdin, N., & Karunia, R. R. D. (2026). Peran Badan Riset dan Inovasi Nasional dalam memperkuat kemitraan internasional sebagai upaya memanfaatkan penelitian dan inovasi untuk Indonesia maju [The role of the National Research and Innovation Agency in strengthening national partnerships as an effort to utilize research and innovation for an advanced Indonesia]. *Journal of Public Policy and Applied Administration*, 8(1).
<https://doi.org/10.32834/jplan.v8i1.1021>
- Erdin, C., & Çağlar, M. (2023). National innovation efficiency: a DEA-based measurement of OECD countries. *International Journal of Innovation Science*, 15(3), 427–456.
<https://doi.org/10.1108/IJIS-07-2021-0118>
- genediazjr. (2016). Stopwords Indonesian (ID).
<https://github.com/stopwords-iso/stopwords-id>
- Hekkert, M. P., Suurs, R. A. A., Negro, S. O., Kuhlmann, S., & Smits, R. E. H. M. (2007). Functions of innovation systems: A new approach for analysing technological change. *Technological Forecasting and Social Change*, 74(4), 413–432.
<https://doi.org/10.1016/j.techfore.2006.03.002>
- Holzer, D., Popowicz, M., Rauter, R., Silberschneider, K., & Stern, T. (2023). Parallel universes, one circular goal: An empirical study comparing Austrian wood- and plastic-based industries. *Sustainable Production and Consumption*, 43, 46–61.
<https://doi.org/10.1016/j.spc.2023.10.014>
- Huttunen, S., Varumo, L., Toivanen, R., Pekkonen, M., & Lumiaro, R. (2025). Developing a policy innovation system (PIS) approach in the case of biodiversity offsetting in Finland. *Science and Public Policy*.
<https://doi.org/10.1093/scipol/scaf057>
- Isoaho, K., Gritsenko, D., & Mäkelä, E. (2021). Topic modeling and text analysis for qualitative policy research. *Policy Studies Journal*, 49(1), 300–324.
<https://doi.org/10.1111/psj.12343>
- Li, X., Wu, T., Zhang, H. J., & Yang, D. Y. (2023). National innovation systems and the achievement of sustainable development goals: Effect of knowledge-based dynamic capability. *Journal of Innovation and Knowledge*, 8(1).
<https://doi.org/10.1016/j.jik.2023.100310>
- Lim, H. K., Phoong, S. W., Shuhaimi, A., & Sulaiman, A. (2026). Technological innovation system applicability in developing countries: Insights from Malaysia's gallium nitride technology development. *Journal of Open Innovation: Technology, Market, and Complexity*, 12(1).
<https://doi.org/10.1016/j.joitmc.2025.100700>
- Ministry of National Development Planning of the Republic of Indonesia/National Development Planning Agency. (2019). Rencana Pembangunan Jangka Menengah Nasional 2020–2024. [National Medium-Term Development Plan 2020–2024]
https://perpustakaan.bappenas.go.id/e-library/file_upload/koleksi/migrasi-data-publikasi/file/RP_RKP/Narasi%20RPJMN%20IV%202020-2024_Revisi%2014%20Agustus%202019.pdf
- Mustangimah, M., Putera, P. B., Zulhamdani, M., Handoyo, S., & Rahayu, S. (2021). Evaluation of the Indonesia national strategic policy of science and technology development. *Journal of Science and Technology Policy Management*, 12(3), 421–442. <https://doi.org/10.1108/JSTPM-04-2020-0079>
- Newman, N., Fletcher, R., Robertson, C. T., Arguedas, A. R., & Nielsen, R. K. (2024). Reuters Institute digital news report 2024. <https://doi.org/10.60625/RISJ-VY6N-4V57>
- Nguyen, D., & Hekman, E. (2024). The news framing of artificial intelligence: A critical exploration of how media discourses make sense of automation. *AI and Society*, 39(2), 437–451. <https://doi.org/10.1007/s00146-022-01511-1>
- Oppermann, K., & Viehrig, H. (2009). The public salience of foreign and security policy in Britain, Germany and France. *West European Politics*, 32(5), 925–942.
<https://doi.org/10.1080/01402380903064804>

- Pepe, C. G. E., Fonseca, M. V. A., & Silva Marques, C. F. (2024). International collaboration towards innovation management: A network perspective and the Global Innovation Index. *Journal of Innovation and Entrepreneurship*, 13(1). <https://doi.org/10.1186/s13731-024-00384-6>
- Putera, P. B., Mardiyanti, M., Handoko, L. T., & Suestiningtyas, N. T. A. (2025). Research and innovation funding policy in Indonesia in the post-2019 national science and technology system era. *Public Policy and Administration*, 24(3), 420–433. <https://doi.org/10.5755/j01.ppaa.24.3.42131>
- Rahayu, A. K., Septiani, N. N., Hamidah, M., Wiryawan, B., Soemodinto, A., Ruchimat, T., Rosdiana, A., Retnoningtyas, H., Yulianto, I., & Wijaya, M. (2025). Multi-stakeholder knowledge management based on co-production principles to support fisheries resource management in Indonesia. <https://periklanan.org/storage/publications/GiTyA63ZvFSaN2ooXZ7Y41hPIKeQUYFj4A6QGeCx.pdf>
- Rakas, M., & Hain, D. S. (2019). The state of innovation system research: What happens beneath the surface? *Research Policy*, 48(9). <https://doi.org/10.1016/j.respol.2019.04.011>
- Rauh, C., & Parizek, M. (2024). Converging on Europe? The European Union in mediated debates during the COVID-19 and Ukraine shocks. *Journal of European Public Policy*, 31(10), 3036–3065. <https://doi.org/10.1080/13501763.2024.2344849>
- Re Lee, K., Hyun Kim, J., Jang, J., Yoon, J., Nan, D., Kim, Y., & Kim, B. (2023). News big data analysis of international start-up innovation discourses through topic modeling and network analysis: Comparing East Asia and North America. *Asian Journal of Technology Innovation*, 31(3), 581–603. <https://doi.org/10.1080/19761597.2022.2134154>
- Savin, I. (2023). Evolution and recombination of topics in Technological Forecasting and Social Change. *Technological Forecasting and Social Change*, 194. <https://doi.org/10.1016/j.techfore.2023.122723>
- Schepelmann, P., Fischer, S., Drews, M., Bastein, T., Kropp, J., Krummenauer, L., & Augenstein, K. (2021). Evidence-based narratives in European research programming. *European Journal of Futures Research*, 9(1). <https://doi.org/10.1186/s40309-021-00175-2>
- Simatupang, T. M., Silalahi, F. T. R., Okdinawati, L., Nandini, W., & Fajarini, P. F. (2022). Indonesia's innovation policies: Evolution and institutional structure. *STI Policy and Management Journal*, 7(2). <https://doi.org/10.14203/stipm.2022.343>
- Suaedah, S., Hapsari, A. T., Mariana, D., & Robbani, H. (2022). Pemetaan Penelitian berdasarkan Prioritas Riset Nasional (PRN) Renstra Brin 2022–2024. *PUNDIMAS: Publikasi Kegiatan Abdimas*, 1(3), 140–145. https://www.researchgate.net/publication/365269125_Pemetaan_Penelitian_berdasarkan_Prioritas_Riset_Nasional_PRN_Renstra_Brin_2022-2024
- Sutriadi, R., Fahmi, F. Z., Arifianto, A., & Muttaqin, F. I. (2022). Role of government and society in urban innovation system: A case study from Indonesia. *IOP Conference Series: Earth and Environmental Science*, 1015(1). <https://doi.org/10.1088/1755-1315/1015/1/012020>
- Temmes, A., Heiskanen, E., Matschoss, K., & Lovio, R. (2021). Mobilising mainstream finance for a future clean energy transition: The case of Finland. *Journal of Cleaner Production*, 319. <https://doi.org/10.1016/j.jclepro.2021.128797>
- Tigabu, A. D., Berkhout, F., & van Beukering, P. (2015). Technology innovation systems and technology diffusion: Adoption of biogas in an emerging innovation system in Rwanda. *Technological Forecasting and Social Change*, 90(PA), 318–330. <https://doi.org/10.1016/j.techfore.2013.10.011>
- Valerio, E., Hilmiati, N., Prior, J., & Dahlanuddin, D. (2022). Analysis of the agricultural innovation system in Indonesia: A case study of the beef sector in Nusa Tenggara Barat. *Agricultural Systems*, 203, 103529. <https://doi.org/10.1016/j.agsy.2022.103529>
- Wetzels, M., Wetzels, R., Schweiger, E., & Grewal, D. (2025). How topic modeling can spur innovation management. *Journal of Product Innovation Management*, 42(5),

- 921–946.
<https://doi.org/10.1111/jpim.12790>
- World Intellectual Property Organization. (2026). Global innovation index. <https://www.wipo.int/en/web/global-innovation-index>
- Wu, J., & Liang, J. (2025). When or what? Understanding consumer engagement on digital platforms. ArXiv Preprint. <https://doi.org/10.48550/arXiv.2510.10474>
- Yusof, M. A., & Saeed, S. (2024). Code switching: Exploring perplexity and coherence metrics for optimizing topic models of historical documents. *International Journal of Systematic Innovation*, 8(4), 103–118. <https://ojs.ijosi.org/index.php/IJOSI/article/view/1231>
- Zafar, M. B., Ali, H., & Yasin, T. (2025). Reimagining human creativity and learning in the age of generative AI: A multi-method meta-thematic synthesis. *Next Research*, 2(4), 100802. <https://doi.org/10.1016/j.nexres.2025.100802>