A Theory-driven Framework for Malaysia's Research, Development, Innovation, Commercialisation and Economy (RDICE) Ecosystem

Haswira Nor Mohamad Hashim[1*], Muhamad Helmi Muhammad Khair[1], Fazlena Hamzah[2], Zadariana Jamil @ Osman[3], Azrin Ali[4], Norsyazrah Zulkifli[5]

[1]Faculty of Law, Universiti Teknologi MARA, Shah Alam

[2]Faculty of Chemical Engineering, Universiti Teknologi MARA, Shah Alam

[3]Faculty of Civil Engineering, Universiti Teknologi MARA, Shah Alam

[4]Faculty of Business and Management, Universiti Teknologi MARA, Puncak Alam

[5]Department of Law, Centre of Foundation Studies, Universiti Teknologi MARA, Dengkil

***Corresponding Author**

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ABSTRACT

Malaysia's aspiration to become an innovation-driven economy is hindered by fragmented RDICE (Research, Development, Innovation, Commercialisation and Economy) efforts, low commercialisation rates, and weak policy coordination. While previous research has examined theory-based RDICE ecosystem models in advanced economies such as South Korea, Finland, Germany, and Singapore, limited attention has been given to how emerging economies like Malaysia can contextualise these approaches amid institutional fragmentation and resource constraints. This gap underscores the need for an integrated, theory-informed RDICE framework tailored to national conditions. This study aims to analyse the theoretical foundations of RDICE, review global best practices, and conceptualise a RDICE eocsystem framework for Malaysia. Using a qualitative, library-based method, secondary data were analysed through textual and content analysis. Findings indicate that an effective RDICE ecosystem should be anchored in five complementary theories—National Innovation System, Mission-Oriented Innovation, Knowledge-Based Economy, Innovation Value Chain, and Integrated Governance. The proposed framework integrates inputs, actors, processes, outputs, and outcomes into three structural domains, and is expected to enhance policy coherence, strengthen industry–academia collaboration, accelerate commercialisation**,** and support Malaysia's transition toward sustainable, knowledge-based economic growth.

Keywords: RDICE; theories; governance; framework; ecosystem.

INTRODUCTION

Research and development together with innovation and commercialization plays a critical role in driving the transition towards a high-income, innovation-led, and knowledge-based economy. The Malaysian government recognises that long-term economic growth can no longer rely solely on traditional industrial sectors or resource-based activities. Instead, it must be fuelled by innovation, intellectual property, and value-added technologies that enhance national competitiveness. The National RDICE Action Plan 2025–2030 has therefore been formulated to realign Malaysia's R&D and innovation landscape towards measurable economic outcomes. It aims to overcome structural inefficiencies such as fragmented governance, duplicated research efforts, and low commercialisation rates that have historically constrained Malaysia's innovation performance (Anonymous, 2024; Mukhtar, 2021).

The National RDICE Action Plan 2025–2030, is an integrated action plan that includes four key elements: Research (R), Development (D), Commercialization (C), Innovation (I) and Economy (E). The RDICE Action Plan was developed to ensure that research and development in Malaysia not only produces knowledge, but also translates into innovations that can be commercialised and have a direct impact on the country's economic growth. The RDICE action plan is an important foundation for Malaysia to leapfrog towards a high-income economy and compete globally through strategically led and sustainable R&D&C&I (Anonymous, 2024).

The elaboration and strengthening of the National RDICE Action Plan 2025-2030 focuses on reducing structural gaps and implementation weaknesses, by adopting RDICE best models and approaches. At the international level, the latest models and approaches for RDICE implementation emphasize governance centralization, integrated fund coordination, and mission-oriented R&D research that targets solutions to major economic challenges and social. Global trends also show increased investment in strategic technologies such as artificial intelligence, renewable energy, biotechnology, and digital technologies (Wang et al., 2025; Gonçalves & Silva, 2024; Idoko et al., 2024), as well as an emphasis on economic returns from R&D investments, including measuring the impact on GDP, high-value jobs, and technological employability globally (Benlaria et al., 2023; Herzer, 2022; Satrovic et al., 2023; Soh et al., 2023).

Existing literature on RDICE underscores the significance of coordinated national systems in transforming knowledge into economic impact. The National Innovation System (NIS) approach, popularised by Lundvall (2022) and Edwards & Thompson (2022), has been widely adopted to explain how innovation performance depends on the dynamic interaction between government, academia, and industry. However, many studies have primarily examined these systems in the context of advanced economies such as South Korea, Finland, Germany, and Singapore (Wagner et al., 2021; Sorin-George, 2023), leaving a research gap in understanding how emerging economies like Malaysia can effectively adapt NIS principles amid institutional fragmentation and resource limitations. Few empirical studies have explored how Malaysia’s innovation actors interact systemically or how policy incoherence constrains such interaction.

Addressing these gaps requires a comprehensive and theory-anchored RDICE framework that unites governance, policy, and industry collaboration. Such integration will provide the intellectual foundation for Malaysia’s National RDICE Action Plan 2025–2030 to function not merely as a policy document but as a transformative engine for innovation-led economic growth.

Problem Statement

Despite decades of investment and policy commitment, Malaysia’s RDICE ecosystem has yet to achieve the efficiency, integration, and transformative impact necessary to position the country among global innovation leaders. While Malaysia has established robust research infrastructure and generated considerable academic output, the translation of research into innovation and commercial value remains limited (Ramli et al., 2021; Ariffin & Mahdzir, 2021). This disconnect between research generation and economic application reflects deeper structural, institutional, and governance challenges that continue to impede the realization of RDICE’s full potential as a national growth engine.

At the policy and governance level, Malaysia’s R&D and innovation efforts remain fragmented and ministry-centric, characterized by overlapping jurisdictions, disjointed funding streams, and a lack of unified policy direction (Mukhtar, 2021; Narayanan & Yew-Wah, 2018). The absence of a single national coordinating authority for RDICE has led to inefficiencies, duplication of initiatives, and weak monitoring mechanisms. In contrast, leading innovation-driven nations such as South Korea, Finland, and Singapore have successfully implemented centralized and mission-oriented governance structures that align national research priorities with socio-economic objectives (Park & Kim, 2022; Kwon, 2024). Malaysia’s current siloed approach therefore limits the systemic synergy required for high-impact innovation.

At the institutional level, research priorities in higher education institutions (HEIs) remain predominantly oriented toward academic output — publications, citations, and rankings — rather than innovation outcomes or commercialization performance (Rahim et al., 2021). The low commercialization rate of university-generated intellectual property is symptomatic of weak technology transfer mechanisms, inadequate collaboration with

industry, and limited policy incentives for spin-offs and start-ups (Suhaimi et al., 2022; Shahidan et al., 2025). Furthermore, there is a persistent misalignment between research focus areas and industrial demand, particularly in emerging technologies such as artificial intelligence, biotechnology, and renewable energy (Muda et al., 2021). These gaps collectively reduce the capacity of universities and research institutions to function as effective innovation hubs.

From an industry perspective, the private sector's contribution to national R&D expenditure remains low, with Malaysia's Gross Expenditure on R&D (GERD) still below 1% of GDP — significantly trailing OECD benchmarks (Mostafiz et al., 2024; Yuen & Ng, 2021). Small and medium enterprises (SMEs), which form the backbone of Malaysia's economy, face barriers such as limited access to research funding, weak innovation capacity, and high risks associated with technology adoption. These structural constraints further inhibit the creation of a vibrant and sustainable innovation-driven private sector.

Collectively, these systemic weaknesses underscore the urgent need for a RDICE Action Plan that unites governance, funding, and industrial strategies under a single coherent framework. Such a plan must be guided by sound theoretical foundations and integrated governance principles to ensure accountability, efficiency, and measurable socio-economic impact. Without a coordinated RDICE policy anchored on strong theoretical and governance foundations, Malaysia risks lagging behind in global innovation competitiveness, remaining a consumer rather than a producer of advanced technologies. Addressing these challenges is therefore critical to transforming Malaysia into a resilient, innovation-led, and knowledge-based economy envisioned in the National RDICE Action Plan 2025–2030.

Objectives

This paper seeks to achieve the following objectives:

a) To analyse the theoretical frameworks underpinning RDICE.

b) To examine global best practices in R&D, innovation, and commercialization governance.

c) To conceptualise a RDICE ecosystem that aligns theory with Malaysia's socio-economic and policy contexts.

METHODOLOGY

The methodology for this study is developed to answer the following research questions:

a) What are the key theoretical frameworks that underpin the conceptualisation of the Research, Development, Innovation, Commercialisation and Economy (RDICE) ecosystem?

b) How have global best practices in research, innovation, and commercialisation governance been implemented, and what lessons can be drawn for Malaysia's RDICE development?

c) How can a theoretically grounded RDICE ecosystem be conceptualised to align with Malaysia's socio-economic conditions and policy environment?

This study adopts a qualitative, library-based research design aimed at conceptualizing a theoretical framework for the RDICE ecosystem in Malaysia. The qualitative approach was selected to enable an in-depth understanding of existing theories, models, and global best practices related to innovation governance and economic transformation. This design is appropriate for exploratory and conceptual research that seeks to synthesise ideas, identify theoretical linkages, and derive new conceptual insights rather than produce numerical generalisations.

The study employs a desk-based analytical method, relying on secondary data. This method facilitates the examination of prior scholarly works, policy documents, and empirical findings to construct a comprehensive theoretical foundation for the RDICE framework. The approach allows for cross-referencing between different

theoretical paradigms—such as the *National Innovation System (NIS), Mission-Oriented Innovation Theory, Knowledge-Based Economy Theory, Innovation Value Chain Theory, and Integrated Governance Theory*—to determine their applicability and interrelationships in the Malaysian context.

Data for this study were collected from secondary sources such as journal articles, conference proceedings, reports, theses and dissertations obtained through online academic databases and repositories. The selection criteria focused on materials that are conceptually or empirically relevant to RDICE and its components, including research and development (R&D), innovation systems, technology transfer, commercialisation, and economic growth. All selected materials were published between 2010 and 2025 to ensure currency, relevance, and representation of both foundational theories and recent developments in the field.

The collected data were analysed using a textual and content analysis approach. Textual analysis was employed to interpret the conceptual meanings and theoretical arguments presented within the literature, with attention given to definitions, frameworks, and the relationships between R&D, innovation, and commercialization. Content analysis was used to systematically categorise recurring themes, concepts, and variables relevant to the RDICE ecosystem—such as governance models, policy coordination, innovation performance indicators, and economic outcomes. This dual analytical technique enables the study to not only summarise existing literature but also to uncover conceptual gaps, theoretical overlaps, and potential directions for a unified RDICE model.

To ensure the rigour and credibility of the findings, the study applied several quality control measures. Sources were carefully screened for academic reliability, prioritising peer-reviewed publications and official government reports. Data triangulation was achieved by comparing findings from multiple authors, disciplines, and national case studies to validate consistency and theoretical relevance. Furthermore, reflexive analysis was employed to maintain researcher neutrality and minimise interpretive bias in synthesising secondary data.

Through this qualitative, library-based inquiry, the study provides an interpretative synthesis that not only deepens understanding of RDICE theories but also generates actionable insights for Malaysia's innovation governance and economic transformation agenda.

Theoretical Analysis

A robust RDICE ecosystem must be grounded in clear theoretical foundations that explain how innovation emerges, evolves, and contributes to national development. Understanding these theories is essential for constructing a coherent framework that aligns research activities, innovation processes, and commercialisation pathways with Malaysia's socio-economic aspirations. This section examines five key theories that collectively inform the structure and direction of the RDICE Action Plan. Each theory offers a distinct but complementary lens, from explaining how innovation actors interact at the national level, to guiding mission-driven priorities, strengthening knowledge-based growth, enhancing the innovation value chain, and ensuring effective governance. By analysing these theoretical perspectives, the study establishes a solid intellectual foundation for conceptualising an integrated and high-impact RDICE ecosystem suited to the Malaysian context.

National Innovation System (NIS) Theory

The National Innovation System Theory emphasizes that a country's innovation capacity depends on the extent of dynamic and effective interaction between various institutions – including government, research and higher education institutions, industry and society – in generating, disseminating and applying knowledge. Innovation is not just a laboratory product or a single technology, rather it is the result of a complex and interdependent ecosystem (Lundvall, 2022; Edwards & Thompson, 2022; Lewis, 2021). This framework expands the understanding that modern innovation demands close collaboration between academia, industry and government (Triple Helix), as well as community involvement as a fourth actor (Quadruple Helix) (Cai & Lattu, 2022). Therefore, the RDICE action plan should focus on building collaborative and integrative mechanisms between all actors in the system, as well as supporting policies that create a conducive environment for the sustainable and productive growth of innovation.

Mission-Oriented Innovation Theory

This theory asserts that innovation needs to be driven by a major national mission that is in the nature of solving the country's main challenges – whether in the aspects of health, energy transition, food security, climate change, or technological advancement (Kattel and M. Mazzucato, 2025, Mazzucato et al., 2021; Larrue, 2021). Countries such as Finland, Germany, and South Korea have shown success through the establishment of national missions in addressing major challenges such as climate change, food security, and digital transformation (Janssen et al., 2021; Vuong et al., 2021). This approach emphasizes the integration of policy, funding and implementation in a strategic and focused direction. In the context of the RDICE action plan, this approach means that Malaysia needs to clearly identify and articulate the national mission that is at the core of research and innovation, as well as ensure that all ecosystem actors are aligned towards those goals. This will help create innovative solutions that have a real impact on society and the economy.

Knowledge-Based Economy Theory

This theory asserts that knowledge, innovation and human capital are the main engines of economic growth. A country's ability to compete and grow in the global economy depends on continuous investment in research and development (R&D), talent development, as well as the ability to convert knowledge into commercial value (Stehr et al., 2020). This theory raises knowledge, innovation and human capital as the main drivers of modern economic growth. Within this framework, investment in RDICE is seen not as just an academic activity or policy support, but as a key strategy to increase national productivity, industrial competitiveness, and create high-value jobs (Al-Mubaraki & Busler, 2018). The RDICE action plan, therefore, should be seen not only as a science and technology agenda, but as a national economic development strategy. It must prioritize long-term investments that generate high-value jobs, develop national technologies, and contribute to the country's competitiveness in the global value chain.

Innovation Value Chain Theory

This theory structures the innovation process into three main phases: the creation of knowledge, the dissemination of knowledge, and the adoption and commercialization of the results of innovation. Each phase requires tailored policy interventions so that the innovation chain is not broken at any stage (Hansen and J. Birkinshaw, 2007). This theory emphasizes that innovation thrives in an overarching ecosystem, where various elements — including institutions, policies, markets, technologies, talents, and innovation cultures — interact with each other. A good ecosystem provides comprehensive support to the innovation process from the idea stage to commercialization (Tilahun & Berhan, 2022). In the Malaysian context, many quality research outputs did not make it to the market due to weaknesses in the middle and late phases of this chain. Therefore, the RDICE action plan needs to formulate a comprehensive strategy – from supporting basic research, accelerating the translation of knowledge into prototypes, providing incentives for technology transfer, all the way to market ease and intellectual property protection. This ensures that the value of innovation is maximized and the return to the national economy can be doubled.

Integrated Governance Theory

This theory underlines the importance of centralized but flexible governance, to ensure effective coordination between various government entities, implementing agencies, the private sector, and society (Foster et al., 2024); Koch, 2008; Jansen, 2007). Fragmented governance (silos) has been identified as a major obstacle to the effectiveness of the RDICE system in many developing countries, including Malaysia. Therefore, the RDICE Action Plan should establish an integrated and cross-sectoral national governance structure, with an emphasis on clarity of roles, efficiency of resource distribution, and impact-based monitoring and evaluation. This approach not only increases the effectiveness of implementation, but also gives confidence to all stakeholders to be actively involved in the success of the country's RDICE agenda.

DISCUSSIONS

Overall, RDICE's global strategy is moving towards research that is cross-disciplinary, based on industry needs, and based on a sustainable and high-impact innovation ecosystem (Budi, 2020; Malec et al., 2020; Yun, 2021;

Sitenko & Holienka, 2022). Nations that have successfully embedded RDICE-like ecosystems—such as Germany, USA, South Korea, Finland and Singapore —have demonstrated that innovation-driven economic growth is most effective when supported by coherent governance, mission-oriented research, and industry-academia collaboration (Wagner et al., 2021; Sorin-George, 2023).

In these countries, the direction of the RDICE ecosystem is closely aligned with the three research questions outlined in this study. The table below summarises the linkage between each research question, the corresponding innovation theories, and their practical application in shaping a coherent RDICE ecosystem framework.

Table 1 Summary of Theoretical Linkages and Significance

Research Question	**Corresponding Theories**	**Practical Application**
RQ1: What are the key theoretical frameworks underpinning RDICE?	NIS Theory, Mission-Oriented Innovation Theory, Knowledge-Based Economy Theory	Establishes conceptual foundations for understanding the systemic nature of RDICE.
RQ2: How have global best practices in R&D, innovation, and commercialisation governance been implemented?	Innovation Value Chain Theory, Integrated Governance Theory	Identifies practical models and mechanisms adaptable to Malaysia's governance and policy environment.
RQ3: How can a theoretically grounded RDICE ecosystem be conceptualised for Malaysia?	Integrated synthesis of all five theories	Produces a holistic framework linking research, innovation, and economic outcomes in alignment with national priorities.

These theories provide a structured analytical lens through which global RDICE models can be interpreted, compared, and contextualised. For instance, Germany operationalises the *National Innovation System* and *Innovation Value Chain* through the Fraunhofer model, which emphasises applied R&D and industry-commissioned research using blended public–private funding sources (Llanos-Paredes, 2023; Vokoun & Dvouletý, 2025). The United States, through the Bayh-Dole Act, exemplifies the role of *Mission-Oriented Innovation* and *Knowledge-Based Economy* principles, enabling universities to commercialise federally funded research and thereby accelerating technology transfer and start-up formation (Singh, 2020).

Similarly, Finland institutionalises *Integrated Innovation Governance* through Business Finland, which links R&D funding to export growth and SME competitiveness, while Singapore's Research, Innovation and Entreprise (RIE) framework operationalises an *Innovation Value Chain* that integrates talent development, directed investments, and socio-economic impact measurement (Wagner et al., 2021; Sorin-George, 2023). Across these cases, one pattern is clear: countries that excel in innovation embed RDICE within a whole-of-nation governance model, grounded in clear theory, stable legislation, strong institutions, and industry-aligned incentives.

Malaysia's direction—particularly under RMK-12 and the Madani Economy—reflects these same aspirations. Strengthening RDICE is critical to transforming Malaysian universities and research institutes into engines of economic productivity, high-value employment, and technology entrepreneurship. However, for Malaysia to close the gap with global innovation leaders, the National RDICE Action Plan 2025–2030 must be theoretically grounded (RQ1), globally benchmarked (RQ2), and ecosystem-aligned to national priorities (RQ3).

Thus, the National RDICE Action Plan should not merely address structural gaps and implementation weaknesses, but also ensure alignment with globally tested RDICE models, national legal frameworks, and Malaysia's socio-economic aspirations. The intended outcome is a realistic, integrated, and impact-driven RDICE ecosystem that accelerates Malaysia's transition toward a high-income, high-tech, innovation-driven nation by 2030.

RECOMMENDATIONS

Building on the theoretical insights and global benchmarking presented in the earlier sections, this part of the paper outlines key recommendations for strengthening Malaysia's RDICE ecosystem. A resilient and future-oriented RDICE framework must operate as a coherent and interconnected system rather than as fragmented policy domains or isolated institutional efforts. The recommendations that follow translate theoretical principles into practical design elements, ensuring that research, innovation, and commercialisation activities are systematically aligned with national socio-economic objectives.

Interdependent Components of the Malaysian RDICE Ecosystem

The conceptualisation of Malaysia's RDICE ecosystem is grounded in five complementary theoretical perspectives—*National Innovation System (NIS) Theory*, *Mission-Oriented Innovation Theory*, *Knowledge-Based Economy Theory*, *Innovation Value Chain Theory*, and *Integrated Governance Theory*—which collectively explain how research, innovation, and commercialisation activities can be systematically transformed into socio-economic outcomes. These theories provide a coherent foundation for answering the research questions and for shaping a holistic RDICE model aligned with Malaysia's national development priorities. Central to this framework is the principle of continuity across the entire value chain—linking inputs, actors, processes, outputs, and long-term impacts—to ensure that every policy initiative and investment results in meaningful and measurable outcomes. Accordingly, the RDICE ecosystem is organised into five interdependent components:

Input (Source)

The input component includes all the primary sources that support the implementation of RDICE. This includes funding and funding from governments, the private sector as well as international partners; human capital such as researchers, scientists, inventors and technology entrepreneurs; as well as R&D infrastructure such as laboratories, centres of excellence and innovation hubs. In addition, supportive policies such as innovation policies, technology procurement and intellectual property protection are also the backbone of this ecosystem. Scientific data and market information, on the other hand, act as a catalyst for strategic decisions and the development of relevant innovative products.

The input component reflects *Knowledge-Based Economy Theory* by prioritising knowledge assets, human talent, and scientific capability as the foundation of innovation-driven growth. It comprises funding from government, industry, and international partners; skilled human capital such as researchers, scientists, and technology entrepreneurs; and physical infrastructure including laboratories, centres of excellence, and innovation hubs. Supportive innovation policies, IP protection, and market intelligence function as enablers consistent with the preconditions emphasised in *NIS Theory*.

Actors (Policy Makers/Researchers/Fund Providers/Industry Players)

The RDICE ecosystem is formed by various key actors interacting in various stages of the innovation process. The government plays the role of a policymaker and implementer, a legislator as well as a provider of incentives and strategic funds. Higher education institutions and research institutions act as generators of knowledge and technology, while industries — including small and medium enterprises (SMEs) and start-ups — become consumers of technology, investors and commercializers of products. In addition, fund providers and innovation facilitators such as technology transfer offices (TTOs), incubators, accelerators and commercialisation agencies serve as important links in making the RDICE process a success. Civil society and communities, on the other hand, are the beneficiaries of innovation and an important social partner in the RDICE ecosystem.

Actor interaction within the ecosystem is directly informed by *Integrated Governance Theory* and the institutional logic of the *NIS* approach. Government sets direction and provides incentives, universities and research institutes generate knowledge, industry acts as adopter and commercialiser, and intermediaries (TTOs, incubators, venture funds) bridge the research-to-market gap. Civil society completes the Quadruple Helix,

ensuring social legitimacy and uptake of innovations—consistent with *Mission-Oriented Innovation Theory*, which stresses innovation for societal missions, not merely markets.

Process/Mechanism (System)

The strategic process in the RDICE ecosystem includes a variety of implementation mechanisms that are structured in an inclusive and systematic manner. It starts with the determination of national RDICE priorities through multi-stakeholder negotiations. Next, the process of generating knowledge and technology is carried out through basic and applied research. The results of this research are then transferred through an effective technology transfer system as well as strong intellectual property protection. This process is followed by the development of innovative products, services, and business models, followed by the ease of commercialization and scaling. This entire process is regulated through a system of monitoring, assessment and policy improvement based on data and evidence (evidence based policy).

This component mirrors the logic of *Innovation Value Chain Theory*, where RDICE activities progress through structured stages: (i) priority setting, (ii) research and knowledge generation, (iii) technology transfer and IP protection, (iv) product and service development, (v) commercialisation and scaling, and (vi) monitoring and evaluation. Embedded within this sequence is *Integrated Governance Theory*, which ensures coordination, accountability, and continuous policy learning through evidence-based monitoring and review.

Output (Short, Medium, Long Term Results)

RDICE Action Plan is expected to deliver short and medium term outcomes consistent with the National Innovation System (NIS) Theory and the Innovation Value Chain Theory. These include increased research productivity and stronger collaboration among public, private, and community actors through Triple and Quadruple Helix interactions, leading to the emergence of locally competitive products and technologies. These outcomes reflect the *Innovation Value Chain's* emphasis on strengthening linkages from knowledge creation to commercialization, while the *NIS* perspective reinforces the importance of institutional interaction in driving system-wide innovation. In addition, RDICE Action Plan is expected to stimulate higher private-sector investment in R&D and raise the commercialization rate of intellectual property originating from both public research institutions and industry, further embodying the principles of the *Innovation Value Chain* in accelerating market diffusion of innovation outputs.

Over the long term, the RDICE Action Plan aligns with the *Knowledge-Based Economy Theory* and *Mission-Oriented Innovation Theory*, aiming to support sustainable, innovation-led economic growth. By prioritizing knowledge, talent development, and mission-driven national agendas, the RDICE ecosystem is expected to generate high-value employment, enhance Malaysia's global innovation competitiveness, and strengthen the nation's technological independence. These targets resonate with the *Knowledge-Based Economy Theory's* focus on innovation and human capital as engines of growth, while *Mission-Oriented Innovation Theory* underscores the importance of directing innovation toward national strategic goals. Ultimately, these long-term results also reinforce the *Integrated Governance Theory*, which envisions a coordinated, cross-sectoral system that supports balanced and sustainable socioeconomic development for the country.

Interrelated Domains of the RDICE Ecosystem

The proposed framework structure is organised into three interrelated domains—Theoretical Foundations, Operational Mechanisms, and Socio-Economic Outcomes. The Operational Mechanisms and Socio-Economic Outcomes domains are derived from the five components of the conceptual framework (input, actors, process, output, and impact), ensuring clear continuity between the conceptual model and its structural design. The Theoretical Foundations domain, on the other hand, is grounded in the five theories analysed in this study, providing a seamless connection between theoretical reasoning and practical implementation. Together, these three domains form a holistic framework that supports the design of a coherent, integrated, and impact-driven RDICE ecosystem for Malaysia.

Theoretical Foundations (RQ1)

The first domain, Theoretical Foundations, addresses the initial research question concerning the key theoretical frameworks that underpin RDICE. This domain draws upon five major theories that collectively explain how innovation systems function and interact within a national context. The *National Innovation System (NIS) Theory* provides a macro-level understanding of how institutions, government policies, and industry actors collaborate to advance innovation. Complementing this, *Mission-Oriented Innovation Theory* highlights the importance of directing innovation efforts toward clearly defined national missions or grand challenges, thereby aligning research priorities with societal needs. Alongside these, *Knowledge-Based Economy Theory* emphasizes the central role of knowledge, human talent, and intellectual capital as critical drivers of long-term economic transformation.

Operational Mechanisms (RQ2)

The second domain, Operational Mechanisms domain is comprised of the input, actors, and process/mechanism components of the conceptual framework, reflecting how resources are mobilised, stakeholders interact, and systemic processes are executed to drive innovation activity. This domain responds to the research question on how global best practices in R&D, innovation, and commercialisation governance can be adapted to the Malaysian context. This domain integrates lessons from international innovation ecosystems and is guided by two key theoretical perspectives. *Innovation Value Chain Theory* provides a structured view of how research inputs are transformed into innovation outputs and eventually into commercialised products, underscoring the importance of strengthening linkages between knowledge generation, technology transfer, and market adoption. Meanwhile, *Integrated Governance Theory* offers a model for institutional coordination, ensuring that ministries, research bodies, and industry players work in synergy rather than in isolation. Through these theoretical lenses, the operational domain ensures that conceptual foundations are translated into coherent policy mechanisms and practical governance arrangements.

Outcomes (RQ3)

The final domain, Socio-Economic Outcomes (Output), is derived from the short, medium, and long term results components of the conceptual framework, This domain corresponds to the third research question, which seeks to conceptualise a theoretically grounded RDICE ecosystem that reflects Malaysia's socio-economic context and policy aspirations. This domain represents the end-state of the RDICE value chain, where the principles embedded in all five theories converge into measurable national impact.

The *National Innovation System (NIS) Theor*y underpins the expectation of system-level economic performance; *Mission-Oriented Innovation Theory* directs outcomes toward national missions and societal needs; *Knowledge-Based Economy Theory* aligns outcomes with talent development, productivity, and innovation-led growth; *Innovation Value Chain Theory* ensures that outputs are the final result of a completed and efficient research-to-market process; and Integrated Governance Theory guarantees that outcomes are achieved through coordinated, accountable, and well-aligned institutions.

Through this theoretical alignment, the Outcomes domain connects operational mechanisms with measurable national results, including innovation-driven GDP growth, increased high-technology employment, enhanced SME competitiveness, and the broader transition toward a knowledge-based economy. These outcomes are consistent with the aspirations of the Twelfth Malaysia Plan (RMK-12) and the National RDICE Action Plan 2025–2030, both of which emphasise inclusivity, sustainability, and high-value innovation as pillars of long-term national development.

Conceptual framework of RDICE Ecosystem

To translate theory into an actionable model for national innovation, the RDICE framework must be structured in a way that logically connects theoretical foundation with operational and outcomes domains. The central hypothesis of this framework structure is that a well-integrated RDICE ecosystem—anchored in robust theoretical foundations and guided by mission-oriented governance—will produce sustainable, innovation-led

economic growth for Malaysia. These theoretical layers interact vertically and horizontally within the RDICE framework. Vertically, they move from conceptual foundation to practical implementation to economic impact. Horizontally, they promote collaboration, feedback, and policy coherence across sectors and actors.

At the core, the *National Innovation System* theory acts as the structural foundation, linking academia, industry, and government (the Quintuple Helix model). Surrounding it, the *Mission-Oriented Innovation Theory* functions as the strategic driver, defining national missions such as energy transition, digital transformation, and biotechnology advancement. The *Knowledge-Based Economy Theory* underpins the human and intellectual capital dimension, ensuring that innovation activities are supported by skilled talent and research excellence.The *Innovation Value Chain Theory* provides the processual framework, ensuring that research results progress through clearly defined stages — from idea generation to commercialization and market diffusion. Finally, *the Integrated Governance Theory* operates as the coordination mechanism, ensuring policy alignment, cross-ministerial collaboration, and impact-based evaluation across all levels of implementation.

This conceptual framework is illustrated in Figure 1 below.

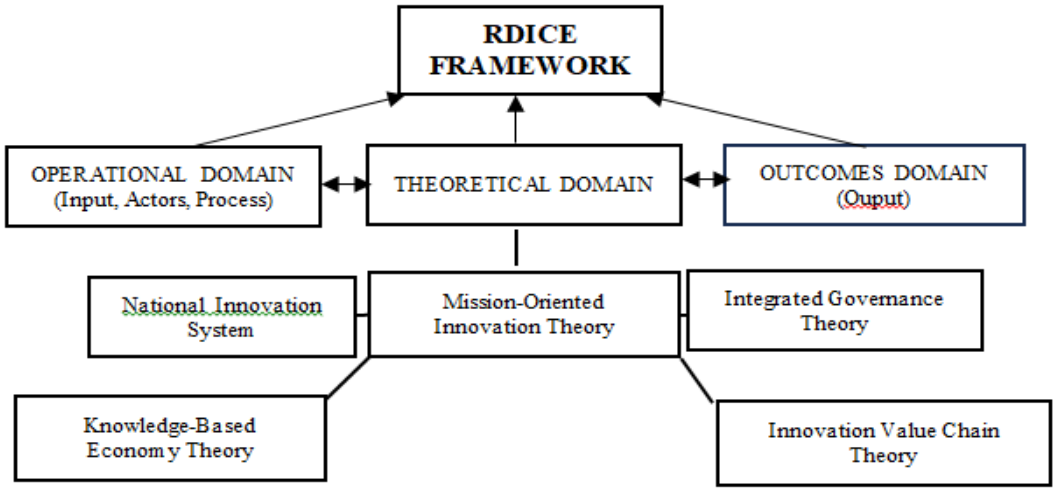

Fig.1 Dynamic interaction among five theoretical pillars with three domains that support RDICE ecosystem framework

CONCLUSION

This study has demonstrated that the development of a comprehensive and theoretically grounded RDICE ecosystem is vital for Malaysia's aspiration to become a high-income, innovation-driven nation. By synthesising the National Innovation *System*, *Mission-Oriented Innovation Theory*, *Knowledge-Based Economy Theory*, *Innovation Value Chain Theory*, and *Integrated Governance Theory*, this paper conceptually demonstrates how multi-theoretical integration can guide Malaysia in developing a robust RDICE ecosystem. It positions theory not merely as an explanatory tool but as a strategic compass for designing governance structures, funding mechanisms, and innovation pathways that translate research excellence into sustained economic competitiveness. The analysis reveals that Malaysia's current RDICE landscape suffers not from a lack of initiatives or talent, but from systemic fragmentation, weak governance integration, low commercialisation performance, and limited industry participation. A theory-based conceptual framework therefore offers strategic direction to ensure that research excellence can be translated into innovation, market value, and economic growth.

The findings of this study carry meaningful implications for policy, institutions, and industry. At the policy level, the proposed framework highlights the urgent need for a unified governance model that coordinates ministries, funding agencies, and innovation actors under a single institutional architecture. Such an arrangement would streamline decision-making, prevent policy duplication, and foster accountability in national innovation spending. Practically, adopting a mission-oriented approach enables Malaysia to channel RDICE investments toward clearly defined national priorities, such as energy transition, health security, and digital transformation,

ensuring that innovation efforts generate measurable social and economic impact. For higher education institutions, the framework underscores the need to shift from a publication-driven culture toward an impact-driven innovation ethos, supported by stronger technology transfer structures, incubator ecosystems, and industry co-creation mechanisms. At the industry level, the study reinforces the importance of strengthening private-sector participation through co-investment models, talent mobility programmes, and innovation clusters that enhance competitiveness and foster high-value entrepreneurship.

While this conceptual study offers a valuable foundation, it is not without limitations. As a library-based qualitative inquiry, the research relies solely on secondary sources and does not incorporate empirical validation through interviews, surveys, or field data. As such, its conclusions are conceptual rather than tested within real-world institutional settings. Moreover, although international best practices inform the framework, differences in national culture, governance readiness, and economic structure may affect the direct applicability of foreign models to Malaysia. The study also does not provide quantitative measurement of RDICE performance, which would be necessary to operationalise the framework for monitoring and evaluation.

Recognising these limitations, the paper recommends several pathways for future research. Empirical studies involving government agencies, industry leaders, and university researchers should be conducted to validate and refine the proposed RDICE framework. Future scholars should also develop measurable RDICE performance indicators—such as innovation readiness metrics, commercialisation KPIs, and ecosystem synergy indexes—that allow policymakers to track progress more precisely. Comparative case studies or longitudinal analyses could further enrich understanding of how mission-oriented RDICE policies influence innovation capacity and economic transformation over time. Such work would not only complement this study but also provide practical tools for policy implementation.

In conclusion, the conceptual framework presented in this paper offers a strategic intellectual blueprint for reimagining Malaysia's RDICE ecosystem. By grounding national innovation planning in strong theoretical foundations and aligning them with socio-economic priorities, Malaysia can accelerate its transition toward a resilient, knowledge-based, and innovation-led economy. If refined through empirical validation and supported by sustained political will, institutional commitment, and industry collaboration, the RDICE model proposed here has the potential to enhance national competitiveness, strengthen commercialisation outcomes, and position Malaysia as a producer—not merely a user—of advanced technologies in the global innovation landscape.

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