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The Triple Helix of Innovation: A Case Study of the Role and Social Relations of Universities, Industry and Government

Triple Helix dan Inovasi: Kajian Kes Peranan dan Hubungan Sosial Universiti, Industri dan Kerajaan

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ABSTRACT

The world economic is constantly changing and innovation is one of the keys to remain competitive. The Triple Helix model has been used as a tool to speed up and improve innovation spurt in many countries, especially a developing country such as Malaysia. The government has taken many steps to move Malaysia towards knowledge-based and innovation-based economy, and this Triple Helix model serves as a mechanism to boost the transition. This study attempts to investigate the challenges that arise in the dynamic collaboration of university, industries and government using the Triple Helix model within the context of the Malaysian's development goals. This study uses semi-structured interviews to gather information and ten participants were selected from the three key spheres of the Triple Helix model: government (government personnel), universities (researchers and research management team), and industries (researchers, managers and executives). The semi-structured interviews were analyzed using a thematic analysis approach. The findings show that there are different facets of challenges faced by the triad collaboration including technological barriers, cultural differences, communication issues, and policy implementation hurdles. The most significant challenge identified was the organizational and structural discrepancies between industries and universities. Despite these challenges, the Triple Helix model remains a potent mechanism for driving innovation and fostering economic growth. Universities are adapting to this model, though issues related to commercialization and procedural inefficiencies persist.

Keywords: Malaysia; Triple Helix model; innovation; university-government-industry collaboration; development

ABSTRAK

Ekonomi dunia sentiasa berubah dan inovasi adalah salah satu kunci untuk kekal berdaya saing. Model Triple Helix telah digunakan sebagai alat untuk mempercepat dan menambah baik lonjakan inovasi di banyak negara, terutamanya negara membangun seperti Malaysia. Kerajaan telah mengambil banyak langkah untuk menggerakkan Malaysia ke arah ekonomi berasaskan pengetahuan dan inovasi, dan model Triple Helix ini berfungsi sebagai mekanisme untuk meningkatkan peralihan. Kajian ini cuba menyiasat cabaran yang timbul dalam kerjasama dinamik universiti-industri-kerajaan menggunakan model Triple Helix dalam konteks matlamat pembangunan Malaysia. Kajian ini menggunakan temu bual separa berstruktur untuk mengumpul maklumat dan sepuluh peserta telah dipilih daripada tiga sfera utama model Triple Helix: kerajaan (kakitangan kerajaan), universiti (penyelidik dan pasukan pengurusan penyelidikan), dan industri (penyelidik, pengurus dan eksekutif). Temu bual separa berstruktur dianalisis menggunakan pendekatan analisis tematik. Penemuan menunjukkan bahawa terdapat pelbagai aspek cabaran yang dihadapi oleh kerjasama triad termasuk halangan teknologi, perbezaan budaya, isu komunikasi dan halangan pelaksanaan dasar. Cabaran paling ketara yang dikenal pasti ialah percanggahan organisasi dan struktur antara industri dan universiti. Walaupun menghadapi cabaran ini, model Triple Helix kekal sebagai mekanisme yang kuat untuk memacu inovasi dan memupuk pertumbuhan ekonomi. Universiti menyesuaikan diri dengan model ini, walaupun isu yang berkaitan dengan pengkomersilan dan ketidakcekapan prosedur berterusan.

Kata kunci: Malaysia; model Triple Helix; inovasi; kolabarasi universiti-kerajaan-industri; pembangunan

INTRODUCTION

Since 2002, Malaysia has been highlighting the development of human capital between the private and public sectors mainly in the area of research and development (R&D). In fulfilling the vision of developing high-technology sectors and nurturing science industry interactions, universities are encouraged to develop strategic collaborations with international research institutions and foreign universities to strengthen R&D activities, especially on the topic of new emerging technologies. Achieving Malaysia's R&D presents several specific challenges, particularly within the framework of the Triple Helix model, which emphasizes collaboration among universities, industries, and the government. One primary challenge is the weak collaboration between universities and industries, where academic research often does not align with industrial needs, creating a significant disconnect (Etzkowitz & Leydesdorff 2000). Funding and resource allocation also pose substantial difficulties, as R&D initiatives require substantial financial resources, which are often limited and must be efficiently distributed. Additionally, navigating the complex landscape of policies and regulations can impede innovation, as regulatory frameworks may not be conducive to rapid technological development (Hashim & Fadzil 2020). Talent retention and development is another critical issue, with high staff turnover disrupting continuity and affecting productivity. Furthermore, the slow adoption of new technologies within industries due to resistance to change, lack of infrastructure, and insufficient training further hampers progress (Mohamed et al. 2019). Cultural and institutional barriers, such as differing organizational priorities between academia and industry, also pose significant obstacles, requiring effective communication and a shared vision (Etzkowitz & Leydesdorff 2000).

Managing intellectual property rights in collaborative R&D efforts is complex, often leading to disputes that slow down innovation processes (Hashim & Fadzil 2020). Addressing these challenges requires concerted efforts and strategic coordination among universities, industries, and government entities to create a conducive environment for innovation and development. The TH model, which emphasizes the symbiotic relationship between universities, industries, and governments, is designed to address various challenges in achieving R&D goals by fostering an integrated and collaborative innovation ecosystem. According to Etzkowitz and Leydesdorff (2000), the TH model facilitates the alignment of academic research with industrial needs through structured partnerships and joint ventures, thereby reducing the disconnect between university research and industrial application. Additionally, the TH model advocates for diversified funding mechanisms that leverage resources from public and private sectors, enhancing the financial sustainability of R&D initiatives. In navigating complex regulatory landscapes, the TH model encourages the co-creation of policy frameworks that are flexible and conducive to rapid technological advancements (Hashim & Fadzil 2020). Furthermore, the TH model supports the accelerated adoption of new technologies through shared infrastructure, collaborative training programs, and the promotion of innovation-friendly cultures within organizations (Mohamed et al. 2019). To address cultural and institutional barriers, the TH model emphasizes the importance of fostering mutual understanding and shared goals among universities, industries, and governments, thereby enhancing communication and cooperation (Etzkowitz & Leydesdorff 2000).

Effective management of intellectual property (IP) rights within the TH framework is achieved through standardized agreements and transparent negotiations, which mitigate disputes and streamline the innovation process (Hashim & Fadzil 2020). By addressing these challenges through a synergistic approach, the TH model plays a crucial role in fostering a conducive environment for innovation and development. The case study of Composites Technology Research

Malaysia (CTRM) serves as an exemplary application of the TH model, illustrating the synergistic collaboration between university, industry, and government to address the issue of high staff turnover affecting productivity. Within this framework, the university's involvement is characterized by academic researchers contributing theoretical knowledge and research capabilities, crucial for developing the Virtual Reality (VR) training tool platform. The industry partner, CTRM, provides essential practical insights into the specific needs and challenges of aerospace manufacturing, ensuring that the training tool is both relevant and effective. The government's role encompasses funding, policy support, and alignment with national development goals, thereby integrating broader economic and educational objectives into the initiative. The Virtual Immersive Reality System for Training in Aerospace Manufacturing (VIRISTAM) epitomizes the tangible output of this collaboration, demonstrating how academic research can be translated into industrial applications with governmental backing. The primary research objective is to investigate the dynamics of university-industry-government collaboration within the context of the TH model, focusing on the Malaysian development agenda. The study aims to elucidate how the TH collaboration supports Malaysia's broader developmental objectives, such as enhancing technological capabilities, improving workforce skills, and promoting innovation within the aerospace sector. The CTRM case study provides valuable insights into the practical application of the Triple Helix model, highlighting the intricate dynamics and challenges of such collaborations and their potential to contribute to national development goals.

LITERATURE REVIEW

Initially, the idea of the triangle was first explored by Sabato where he used it to analyse the relationship between the industry, academia and science in Latin America. He highlighted that the triangle does not exist in those countries, which make them stagnant in economic development (Etzkowitz & De Mello 2004). He proposed that it is important to have dynamic interaction in between the triangle for progress to occur. Etzkowitz and Leydesdorff (1995) later developed the idea by naming the process as the TH model of innovation (refer Figure 1).

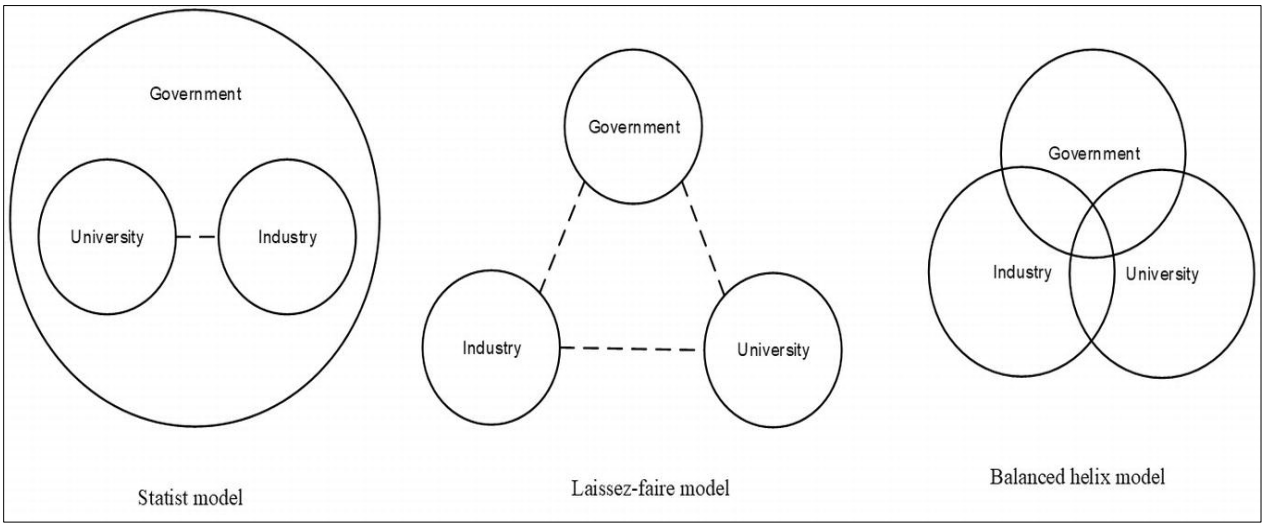

FIGURE 1. Evolution of TH Model

Strand et al (2020) posits that the relationship between innovation actors of the system level could be studied using the analytical framework of the TH model. The model is a spiral mode of innovation which able to multiple reciprocal linkages at diverse stages of knowledge capitalization. In the original form of TH model, there were two opposing positions, which is the statist model (government plays the main role in organizing, controlling and driving the industry and academia in pursuit of innovation); and the laissez -faire model (industry, government, academia function separately with minimal interaction across strong boundaries (Etzkowitz 2017: 302). All of the components are linked only through the market with industry as the main driving force. The fundamental idea of innovation system hinges on the comprehensive structure of interrelated connections between government, academia, and industry. This concept suggests that they serve as the three key drivers of economic development. The spillover of knowledge is generated, transferred, and assimilated through the interdependence and collaboration among these diverse organizations (Zhuang et al. 2021). Academia's role is to create fresh knowledge and technology, while the industry's role is to transform this knowledge into marketable products and engage in production activities. The government, in turn, oversees and enforces these processes (Etzkowitz 2017). Currently, most cooperative efforts predominantly take place at the regional level. These initiatives typically aim to address gaps in economic development, tackle existing issues within industrial clusters, and resolve the challenge of insufficient government supervision.

According to Wong and Goh (2019), the potential growth of science and technology in Malaysia was static during the period of 1981 until 2005. Then, the universities started prioritize collaborating with the industry and government to expand the research innovation starting from 2007. Malaysian universities were in the position either statist or lassiez-faire in the TH categories. In the hybrid form of TH model, it maximises the synergies between all the actors. The university has a prominent role in innovation, alongside the government and the industry. Plus, the government creates innovation policy through interaction and sharing sessions with the university and industry, rather than fully prescribed by them. The theories derived from the TH approach, to a certain degree, support the concept that universities have a significant role in the innovation process. This is particularly relevant in the context of knowledge-based societies (Etzkowitz et al 2020). The TH model has sparked interest in some developed and developing economies to apply the model as a tool for policy making in promoting economic development and enhancing innovation (Etzkowitz & Leydesdorff 1997). It allows us to understand better the collaboration by analysing the strengths and weaknesses of each helixes. In his model, Etzkowitz (2013) establishes stages in the development of the model that are: influence of one helix to one another, their transformation, interaction, networks and linkages (one of them is through technology transfer), and the effect of a larger society. Each institution is linked to another in the collaborative structure between them, and they becoming reliant on each other, forming unobvious links (Cai & Lattu 2022, p. 272). Though performing their traditional functions, they are engaged in the roles of the others (Cai & Lattu 2022; Cai & Amaral 2021). The industry will gain values from the universities, knowledge sharing, and all of them will achieve common long term strategic goals.

This model faces its share of criticisms where it is claimed that it is too abstract (Cooke 2021; Martynovich 2020). While the TH model advocates for extensive engagement among academia, industry, and government, it often lacks practical guidance on how to bridge disparities and cultivate cooperation among these three spheres (Lundberg 2019). A closely related criticism pertains to the model's lack of consideration for the national context, which significantly influences these three institutional actors. Moreover, it fails to account for variations in innovation systems among different countries. The model's effectiveness has also come into question, as some regions

have fallen short of meeting anticipated levels of innovation and employment (McAdam et al. 2020). Critics have argued that the TH model lacks a strong micro-foundation and overlooks the individuals who often serve as the primary drivers of innovation. While there has been extensive research on university-industry collaboration and the relationship between industry and government, the precise nature and evolution of the relationship between the university and government, as well as the trilateral relationship remain largely unclear. One of the most significant challenges posed by the TH model is the selection of a suitable measurable indicator that can effectively serve as a proxy for the current state of the innovation system (Martynovich 2020). However, despite the existing limitations, the importance of TH systems in driving innovation and promoting sustainability is on the rise. This trend is primarily attributed to the global economic restructuring that necessitates a new breed of industry founded on R&D driven innovation and advanced technologies. Scholars are increasingly embracing the TH model to craft sustainable solutions and innovative projects tailored to address global challenges (Audretsch & Link 2019). The robust TH collaboration is becoming a pivotal factor in the success of regional entrepreneurial ecosystems, as it encourages innovation as a response to critical ecological issues (Brem & Radziwon 2017).

One of the argument of the TH model is that academia plays an important role in capitalisation of knowledge. Etzkowitz and Leydesdorff (2000) pointed out that, the universities are establishing new relationships with the industry and becoming more enterpreneurial. This new version of university is defined by Etzkowitz (2000) as the combination of teaching, research, and entrepreneurial. Universities need to be the anchor and the main drive of development in the TH model. Through collaboration with universities, the industry can boost their innovation capacity and be more competitive by having access to scientific and technological knowledge, using applied and basic research results, develop and test prototypes and also getting opinion and support in finding solutions for issues in their products development. As for the universities, they gain profit by getting financial resources, access to industrial information, creating new technical knowledge and practices, having applied knowledge that can be used for teaching and academic research. However, in implementing the TH model, there have been some empirical evidence on the issues and challenges experienced by institutions implementing TH model, especially in developing countries (Rivera 2010; Irawati 2010; Ranga & Etzkowitz 2010). One of the problems rose from cultural differences between components of the helixes. Cultural similarity is important for a successful collaboration. These components include shared language, working culture, habits and other cultural traits. It is supported by Brockhoff and Teichert (1995) where they explain the concept of 'people attributes'. It is a factor that has impact on relationship rather than technical and economic sphere in the collaboration. Relationship is the most important influences on R&D cooperation between the industry and the university. Other range of factors that would impact the strength of collaborative relationship's success are know-how transfer, information networking, cooperative behaviour and procedural learning. Choosing the most suitable organizational form is the most important task to do in a multi-cultural collaboration team. Management styles and attitude in the organization must have shared values rather than just technical issues for the collaboration to success. As highlighted by Etzkowitz and Leydesdorf (1997), organizational form is the incubator in collaboration between institutions.

Above all, the biggest challenge in a collaboration is organizational and structural differences between the industry and the university. Galan-Muros and Plewa (2016) highlighted that the main motivation for universities is to generate theories and disseminate knowledge. While for the industries, they will apply the knowledge to generate a short-term profit. These goal

differences will affect the procedures in project's execution and the expected output of the projects. Thus, it is crucial for the research team to define their research's objectives at the beginning of the project, so that the research's goal would be clearer and everyone can be fully engaged in the project (Plewa et al. 2016). It has been identified by Van de Vrande et al. (2009) that corporate culture is also one of the biggest challenge for institutional collaboration in open innovation projects. Different organizational culture in collaborations could lead to issues as different time management, social conducts, cognitive differences, how resources are allocated, objectives of projects, language, and different value system. On the other hand, national culture impacts the perception of the organizational difference on how to communicate with each other. The differences among types of organization can vary largely and those differences lead them to different priorities (Vries et al. 2019). The challenge is to balance those differences. The university should be equipped with ample research capability for a successful collaboration such as competencies, facilities and knowledge. These components will help to meet the demand for new research by the industry, alongside prior research results carried out by the universities. Apart from that, insufficient of human resources, innovation resources, innovation strategy, and absence of common goals among the participants in the collaboration project are also some known barriers of collaboration process between industry and university (Bertello et al 2021).

Over time, additional components have been introduced into the conceptual framework of the TH, expanding the theoretical "universe" to include the quadruple helix (where the public or civil society becomes the fourth component) and the quintuple helix (which includes the natural environment as the fifth element). The ongoing discussion centers on how to seamlessly incorporate these elements into a unified framework (Cai 2022; Carayannis & Campbell 2022). In this article, the focus of the researcher is on the university-industry-government triad, as it serves to elucidate interactions among stakeholders within innovation ecosystems (Cai & Lattu 2022) and is particularly suited for investigating organizational interactions (Cai 2022).

TRIPLE HELIX MODEL IN THE CONTEXT OF MALAYSIA

The Malaysian government has established blueprints that encourages the public universities to act as a key player in supporting innovation and technological commercialization. Some of Malaysian universities are seen quite incompetent in research and development projects because either they do not have the access to equipment and resources that are important for the development of new technologies or they do not have enough research experience and expertise in the needed field (Maarof et al 2017). This situation has forced the local industries in Malaysia to seek foreign sources for R&D support and assistance. According to Chedid (2021), there are several main stakeholders in any university-industry-government collaboration. First, the academia that refers to higher education institutions. Second, the industry players such as the SME, corporate firms and researchers. Usually the industry will play an active part in formalizing the collaboration. They sometimes exert influence with their company vision and corporation strategies. Third, the government stakeholder. The government make policies on university-industry collaboration and support them via funding. They usually do not take the active part in doing research on the projects, but they provide instruments for the projects to be done. Their main aim is to trigger as much successful collaborations that can help in improving country's economic performance locally and globally. Those are the main stakeholders.

Now the secondary stakeholders also get the impact of the collaboration which is the consumers of the product and also the society. As the product's consumer, they have little influence in the collaboration through market orientation, and their interest lies in having the innovation to ease their daily life. For the society, it benefits them in the form of commercialized innovation that boost the country's GDP, public spending and tax income. In Malaysia, the government has a solid influence on the university because they are the main source of funding and they rule out policy on higher education. It was always the government who plays as the main actor between the three institutions. However, this social relationship has evolved when the government decided that the university should be "an entrepreneur". These are made possible by the establishment of Research Universities (RU) projects led by the Malaysian government in 2007. As a result, there were more post-graduate student's enrollment, increased publications, high project commercialization, and more collaboration with researchers from local and international-based. This situation created commercial revenues for public universities in Malaysia between 2007 and 2015 (Chuah 2016). The revenues are collected from endowments, research grants, product commercialization, consultancy and professional services, industry funds and publications (Subramonian & Rasiah 2019).

Since 1990s, Malaysia has implemented explicit policies to nurture R&D collaboration between university and the industry. It has been made as one of the important pillar to foster innovation across the country. In 2011, Knowledge Transfer Partnership (KTP) program was introduced to smoothen the transfer of expertise and research findings through innovative projects run by faculty members and industries business partners. It has also provided industrial-based training programs to strengthen business skills, practical knowledge and employability of graduates. Moving forward, in 2012, the government has launched the Graduate Employability Blueprint (GEB) for 2012-2017. This plan was meant to tackle the issues of graduate marketability and employability. Large amount of funding was released through the Ministry of Higher Education (MoHE) to support research and development by universities in exploring new ideas pertinent to new technology niche. In the Tenth Malaysian Plan (2011-2015), MoHE came out with four types of funds for higher learning institution. It was the Exploratory Research Grant Scheme (ERGS), Fundamental Research Grant Scheme (FRGS), Prototype Research Grants Scheme (PRGS) and Long Term Research Grant Scheme (LRGS). It was an open funding offered to all research scientists, government research institutions, as well as companies focusing on new product development and commercialization. The Malaysian government supports these collaborations by establishing rules and regulations and providing financial capital to facilitate the process. Various forms of government support include grants and special incentives for companies that successfully collaborate with universities to develop new products. Additionally, the government offers more scholarships for PhD programs related to industry needs and identifies the strengths of each university to match them with specific industries (Ministry of Higher Education Malaysia 2007; Malaysian Investment Development Authority 2020). According to MS Salleh (2013), in Malaysia there are four types of modes engagement between industry and university that consisted of:

1. Innovation and R&D: new product development and innovation.
2. Technology transfer: technology sourcing, commercial property management, market analysis, formation of new university-technology based start-up companies, technology licensing, and incubation.

3. Consultancy: environmental management, social studies, information, communication and technology services, business management, bio-technology, food hygiene and safety.
4. Product commercialization: market orientation, technology orientation.

VIRISTAM project possesses all four modes of engagement in their research collaboration project.

RESEARCH METHODOLOGY

This study investigates the challenges encountered in implementing the TH institutional model within the Malaysian socio-economic context, focusing specifically on the VIRISTAM project. Ten participants were purposefully selected based on their direct involvement in VIRISTAM, ensuring representation from government (three participants involved in R&D policy-making), universities (three including researchers and research management), and industries (three encompassing researchers, managers, and executives). Interviews were conducted both online and face-to-face at the AMIC headquarters in GMI, Bangi, providing flexibility and a conducive environment for in-depth discussions. Data collection continued until thematic saturation was achieved, ensuring a comprehensive exploration of all pertinent themes related to TH model challenges within VIRISTAM. Thematic analysis was employed, involving transcription of interviews, systematic coding of transcripts to identify recurring patterns and themes, and validation of these themes through consensus among the research team. This rigorous process facilitated a nuanced understanding of the dynamics, interactions, and obstacles faced by stakeholders in the VIRISTAM project, illuminating the complexities of implementing the TH model in Malaysia. By uncovering deep insights into how different stakeholders perceive and navigate collaboration and innovation within Malaysia's research and development ecosystem, the research aims to support efforts to foster innovation-driven economies and improve R&D outcomes. This comprehensive methodological approach ensures robust empirical evidence, offering valuable contributions to both academic research and practical initiatives aimed at strengthening collaboration and innovation within Malaysia's VIRISTAM project and broader contexts.

FINDINGS

This study delves into the multifaceted challenges encountered in implementing the TH institutional model within the Malaysian context, focusing on the VIRISTAM project—a collaborative effort involving MARA-Aerotech, University of Malaya (UM), Institute of Ethnic Studies (KITA-UKM), and Aerospace Malaysia Innovation Centre (AMIC). This consortium aims to facilitate joint research grants, human resource development, and personnel exchange between universities and industries, leveraging expertise in VR and AR technologies. The industry side, represented by AMIC and MARA-Aerotech, contributes crucially by providing both the experimental subjects and essential VR technology tools. MARA-Aerotech takes charge of developing training pedagogies and updating data on Malaysia's aerospace training sector, while AMIC serves as the central hub for VR research operations, liaising with international technology providers such as Airbus Group. On the academic front, UM and KITA-UKM lend their expertise

in theoretical VR approaches, mechanical advancements, and validation methodologies for VR use-cases, including perspective-taking ability (PTA) testing.

From the interviews conducted within this framework, several pivotal challenges affecting the TH model's application and the role of universities have surfaced, warranting detailed examination. One prominent issue concerns technological factors, where academia faces deficiencies in R&D capabilities due to inadequate resources and equipment, coupled with limited research experience. One of the researcher in the interview claims that "…the shortage of resources and modern equipment in universities is a major setback for our R&D projects. We frequently need to seek external help to complete technology transfer initiatives, which complicates our collaborations" (Researcher, Interview, June 2017). Consequently, collaborations often necessitate seeking external support, especially for technology transfer initiatives. Another critical challenge revolves around the disparities in working cultures among universities, industry, and government entities. "…academic institutions are often bogged down by bureaucratic procedures, which are in stark contrast to the dynamic and fast-paced nature of the industry. This misalignment makes it difficult to keep projects on track…" (Industry Partner, Interview, June 2017). Academic institutions, entrenched in bureaucratic cultures, often struggle with flexibility and agility—a contrast to the fast-paced, short-term goal-oriented nature typical of industry environments (Bertello et al. 2021). This discrepancy in time orientation can impede decision-making processes and project execution timelines, potentially leading to frustrations and reduced commitment among stakeholders.

Effective communication emerges as another significant hurdle, crucial for bridging understanding and alignment across diverse stakeholders. "Language barriers and the use of specialized industry jargon often lead to miscommunications, which can derail project progress and cause significant delays" (Research Coordinator, Interview, August 2017).

Language differences, particularly in international collaborations like VIRISTAM, pose substantial barriers. The project mitigates this through a standardized use of English, yet challenges persist due to industry-specific terminologies and occasional language shifts, such as when interacting with French-speaking Airbus Group personnel. Policy implementation also emerges as a critical challenge influencing the TH model's effectiveness. Government policies, as articulated by Gibbons (1998), wield considerable influence over academia's engagement in socio-economic development. In the VIRISTAM context, Malaysian government initiatives like Malaysia Laboratories for Academia-Business Collaboration (MyLab) play a pivotal role by funding collaborations aimed at enhancing technology transfer and innovation. "While government initiatives like MyLab are intended to support collaborations, the reality of budget constraints and supply delays often hampers their effectiveness, making it challenging to maintain momentum in our projects" (Project Manager, Interview, August 2017).

However, challenges such as budgetary constraints and equipment supply issues have hindered smooth project operations, highlighting the need for more streamlined and coherent policy frameworks. This study's findings underscore the intricate dynamics and formidable challenges inherent in implementing the TH model within Malaysia's research and development ecosystem, as exemplified by the VIRISTAM project. Addressing these challenges—whether through bolstering R&D capacities, aligning diverse work cultures, improving communication strategies, or refining policy frameworks—holds the key to unlocking greater synergies and realizing the full potential of university-industry-government collaborations in driving innovation and economic growth. The challenges identified significantly impact collaboration within the TH model, which aims to synergize universities, industries, and government entities to foster

innovation and economic growth. One of the primary issues is the weak technological resources in academia. The lack of essential resources and equipment in academic institutions directly hampers their ability to conduct cutting-edge research and develop new technologies. This deficiency limits universities' capacity to engage in meaningful knowledge exchange with industry partners. When universities cannot contribute advanced research outputs or innovative technological solutions, industries may turn to external sources or other countries for their R&D needs. This reliance on foreign expertise undermines the local innovation ecosystem and weakens the potential for homegrown technological advancements, stifling the collaborative process intended to stimulate local innovation and economic growth.

Differences in working culture between universities, industry, and government further complicate collaborations. Academic institutions often operate under rigid bureaucratic structures, which can slow down decision-making and project implementation. In contrast, industry partners are typically more dynamic and oriented towards short-term goals and quick results. This misalignment can lead to delays, missed deadlines, and frustration among collaborators. For instance, if a university's approval process for a research proposal is cumbersome, it can slow down the overall project timeline, reducing the industry's enthusiasm and commitment to the partnership. Effective collaboration requires synchronizing these different working rhythms to ensure timely progress and mutual satisfaction (Bertello et al. 2021). Communication barriers also pose significant challenges. Successful collaborations within the TH model depend heavily on open, clear, and effective communication. Language differences and industry-specific jargon can lead to misunderstandings, misaligned expectations, and inefficiencies. In the context of the VIRISTAM project, while English is used as the common language, the presence of industry-specific terminology and occasional use of French can create initial barriers. Miscommunications can lead to errors in project execution, duplication of efforts, or even conflicts among partners. When stakeholders are not on the same page, the flow of information is disrupted, compromising the quality and coherence of collaborative research and its outcomes.

Policy implementation issues further exacerbate these challenges. Government policies play a crucial role in facilitating and supporting university-industry collaborations. However, the inflexibility, inconsistency, and lack of clear direction in policy implementation can significantly hamper these efforts. For example, the MyLab initiative aims to bridge the gap between academia and industry by providing funding and resources. Yet, issues such as budgetary constraints and delays in equipment supply can stall projects and dampen enthusiasm among stakeholders. If policies are not effectively communicated or are too rigid, they can create barriers rather than enablers for collaboration. This can lead to missed opportunities for innovation and reduce the overall effectiveness of the TH model in driving socio-economic development (Gibbons 1998). The challenges of weak technological resources, differing working cultures, communication barriers, and policy implementation issues create significant obstacles in the TH model. These obstacles hinder the fluid exchange of knowledge, delay project timelines, reduce stakeholder commitment, and ultimately weaken the collaborative innovation ecosystem that the TH model seeks to promote. Addressing these challenges is crucial to unlocking the full potential of university-industry-government collaborations and fostering a more robust and dynamic environment for technological and economic advancement.

Strengthening technological resources in academia is critical. The government and private sectors should increase funding and investment in university infrastructure and research facilities. Establishing dedicated innovation hubs and technology parks within universities can provide the necessary resources and foster a more conducive environment for research and development. To

overcome communication barriers, it is essential to standardize communication protocols and ensure that all stakeholders use a common language and terminology. Regular communication channels such as joint meetings, progress reports, and collaborative platforms should be established to maintain clarity and transparency. Providing language training and cultural exchange programs can further improve mutual understanding, especially in international collaborations. Policymakers need to create clear, consistent, and flexible policies that support university-industry collaborations. Simplifying bureaucratic processes and ensuring timely disbursement of funds and resources are critical steps. Establishing a dedicated oversight body to monitor and evaluate the effectiveness of policies and their implementation can help identify and rectify issues promptly. Encouraging feedback from universities and industry can also lead to more practical and effective policy frameworks.

COLLABORATIVE LEADERSHIP AND NETWORKING THROUGH TECHNOLOGY TRANSFER IN THE CASE OF VIRISTAM

The technology transfer in VIRISTAM is an important factor that initiated the relationship between the universities, industry and the government (refer Figure 2).

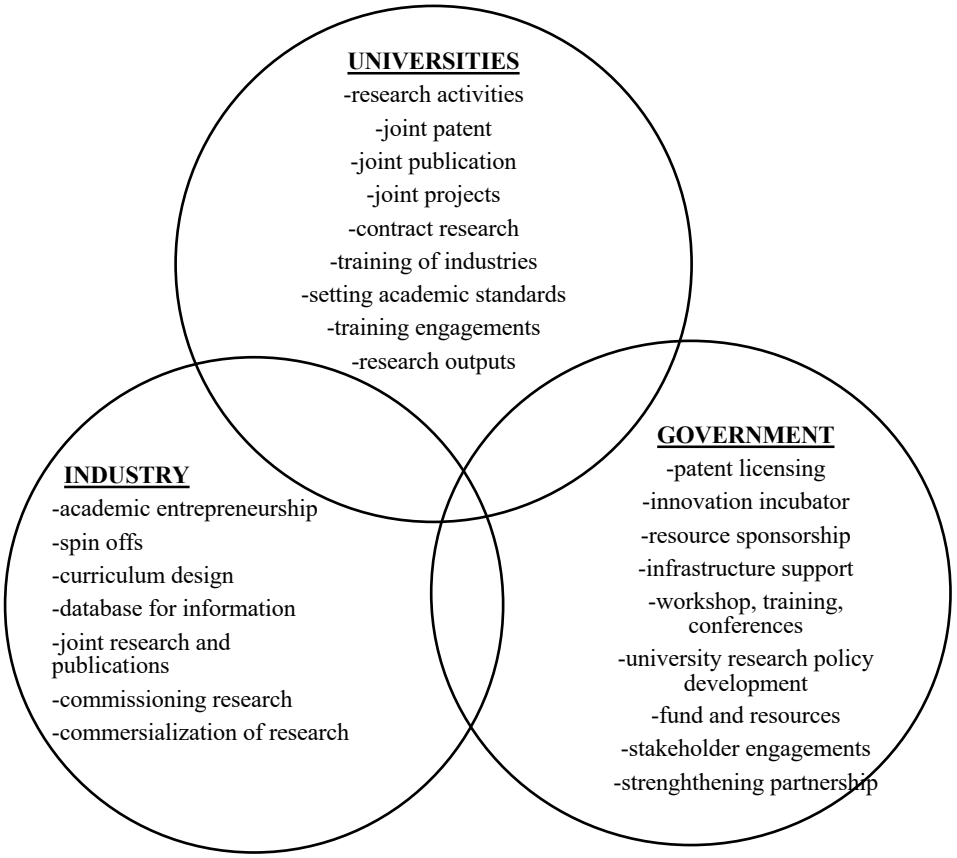

FIGURE 2. The TH Model of Innovation in VIRISTAM

In VIRISTAM, the university provides advice and consultation on the technical and sociological expertise of the project. Through collaboration with universities, the industry boost their innovation capacity and be more competitive by having access to scientific and technological knowledge, using applied and basic research results, develop and test prototypes and also getting opinion and support in finding solutions for issues in the products development. As for the universities, they gain profit by getting financial resources, access to industrial information, creating new technical knowledge and practices, having applied knowledge that can be used for teaching and academic research. The collaboration between the industry and university mainly run between three categories. First, it is a joint knowledge creation that molds partnership, joint research and contract research. In this partnership, all parties are involve in personnel exchange, information exchange and producing research grant. Second, the transfer of knowledge that involves professional consultants, producing journal papers, books, conferences and licensing patent. Lastly, the result of every research conducted are commercialized for industry innovation. In VIRISTAM, it is a combination of all three categories. All parties, especially the industry and the university, get to decide on the direction of the research and frequent discussion are done to make sure the direction of the project is clear and meet the expectation from both parties. Both institution also have formed strategic management team so that there is always a person to drive forward the collaboration and keep the momentum of the project going. This collaboration gives mutual gains for both parties in R&D and knowledge dissemination.

In VIRISTAM, each members of the team provides their personal opinion, direct exchange, in the process of achieving their research goals. This process gradually builds trust and commitment between members. Every details were put into places accordingly through Gantts chart and constant meet up with all the parties involved. Progress were updated from time to time and everyone was keeping up with the schedule to ensure every short-term and long-term goals are met. Each parties did their part according to work packages assigned, within the time frame, to make sure the project meet the deadline. Some researchers from the university are not really comfortable with the industry's extreme rate of secrecy if they collaborate, because it erodes the openness of traditional academic culture. However, every procedures are respected and every parties shall have agreements on what not and what should be exposed. These matters are secured with the MoU agreement between all parties in the collaboration. Each party involved in VIRISTAM show their highest commitment and be able to provide additional knowledge in the team. Throughout this research project, a variety of terminology, research approaches, and methods has been developed to ensure a successful collaboration. VIRISTAM project has opened the access to R&D talents among researchers and postgraduates to work together on collaborative projects under the supervision of academia-industry.

CONCLUSION

This paper explores the dynamic collaboration among universities, industries, and government within the context of Malaysia's development goals, employing the Triple Helix model as a framework. It examines how each component—universities, industries, and government—plays a crucial role in driving innovation and economic growth. Universities, traditionally focused on education and research, have evolved into pivotal hubs of innovation and entrepreneurship. They are now instrumental in bridging the gap between theoretical knowledge and practical application, fostering a culture where research outputs can be effectively transferred to industries. This

transition is essential for Malaysia's aspirations in the Fourth Industrial Revolution (Industry 4.0), where universities serve as catalysts for technological advancements and national development. In this collaborative framework, industries bring crucial perspectives from market demands and technological applications. They provide the practical context and resources necessary to translate academic research into commercial products and services. Moreover, industries benefit from access to cutting-edge research, innovative ideas, and skilled graduates who are equipped to meet evolving market needs. This mutual exchange strengthens Malaysia's industrial competitiveness and supports its journey up the global value chain.

Government, on the other hand, plays a pivotal role in shaping policies and creating an enabling environment for collaborative innovation. Policies that promote research funding, technology transfer, and industry-academia partnerships are critical in fostering a vibrant innovation ecosystem. Government initiatives such as incubation centers, research grants, and regulatory frameworks also facilitate the translation of research into tangible societal benefits and economic growth. Empirically, this study aims to unravel the intricacies of these interactions within the TH framework. It seeks to delineate how universities, industries, and government entities collaborate, innovate, and navigate challenges together. These challenges may include aligning differing priorities, navigating bureaucratic processes, and managing intellectual property rights—all of which impact the effectiveness of collaborative efforts. Understanding the dynamics of knowledge spillovers, innovation catalysts, and barriers is essential. It sheds light on how universities can enhance their research relevance and impact, how industries can leverage academic expertise for competitive advantage, and how government policies can better support collaborative innovation initiatives. Furthermore, in the context of Malaysia's development goals, the paper explores how these collaborations contribute to regional economic growth, job creation, and societal well-being. By fostering synergies among universities, industries, and government, Malaysia can harness the full potential of its knowledge economy and emerge as a global innovation leader. In conclusion, this study underscores the transformative potential of the TH model in Malaysia. By strengthening university-industry-government collaborations, leveraging academic research for industrial innovation, and aligning policies to support collaborative ventures, Malaysia can accelerate its path towards sustainable development and global competitiveness in the knowledge-driven economy of the 21st century.

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AUTHORS CONTRIBUTION

All authors conceived of the presented idea. Noor Ashikin Said conceptualized and conducted the methodology. Zaharul Abdullah worked on the literature review. Both authors validated and discussed the findings and finally contributed to the final manuscript.

CONFLICT OF INTEREST

All authors declare that they have no conflicts of interest in the production of this manuscript.

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