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Performance reporting for innovation partnerships – the case of the triple helix in Zambia

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ABSTRACT

The aim of this study was to understand stakeholder roles and performance measurement practices needed for the success of the triple helix model of innovation. This knowledge is critical for providing policy advice that would harness innovation activities and contribute to socioeconomic development. Most innovation performance frameworks are theoretical and generic in nature and fail to bring out the practical elements needed for policy formulation and decision making. Key issues in the course of developing an innovation partnership such include identifying and understanding the roles to be played by different stakeholders involved in the collaboration and, consequently, identifying and developing measures to report the performance of the collaboration in addressing local needs. In order to undertake such a study, data were collected through semi-structured interviews with diverse stakeholders drawn from government, industry, academia, civil society organizations, and innovation hubs. Qualitative data analysis involved thematic analysis to identify the key themes emerging from the data. The findings indicate that different stakeholders play different centrality and brokerage roles in influencing the success of the triple helix depending on their capabilities and resources. In order to monitor the success of the triple helix model, the study presents three categories of performance measures including measures of socio-economic performance, measures of social and symbolic performance, and measures of financial and social performance. Therefore, this study contributes to the literature by providing empirical flesh to social network theory on how to harness the functioning of innovation networks such as the triple helix within a developing-country context.

IMPACT STATEMENT

This study calls for an increased need to continuously strengthen the education system at all levels to promote and emphasize hands-on science, mathematics, innovation, and the commercialization of intellectual property and entrepreneurship. Scientific research and development for products, services, and processes need to be promoted and supported by developing mechanisms for academia and industry to regularly share knowledge and focus on solving industry and societal problems. Specialized research centres, innovation hubs, or technology and innovation support centres (TISCs) around national priority and strategic areas/sectors can be opened and funded in selected universities and research institutions. It is imperative to promote the registration, protection, and utilization of intellectual property through TISCs, having clarified ownership issues from publicly funded research activities. Finally, there is a need to increase research and innovation expenditure by targeting a certain percentage of the annual budget. For the performance measurement system recommended above to be effective, the government is expected to create an environment in which industry and academia will closely interact with each other. This could be achieved by undertaking joint research and innovation ventures, where industry finances research projects and universities undertake such activities on behalf of industry partners.

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1. Introduction

The purpose of this study is to gain an understanding of stakeholder roles and performance measurement practices within innovation partnerships among governments, academia, and industry. This

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knowledge is critical for providing policy advice that would harness innovation activities and contribute to socioeconomic development. Accordingly, this study contributes to the literature on performance measurement and management in innovation collaborations by highlighting a system of stakeholder roles and performance measurement practices to enhance innovation activities and outcomes. The triple helix (TH) model describes a tripartite system of overlapping interactions, showing that while industry operates as the center of production, the government acts as the source of contractual relations that guarantee stable interaction and exchange of ideas (Leydesdorff & Etzkowitz, 1996). Furthermore, universities are deemed to be the source of new knowledge and technology (Etzkowitz & Carvalho de Mello, 2004). Others (e.g., Metcalfe, 2010) refer to intermediating organizations to include civil society organizations together with other actors, such as incubation hubs. These organizations facilitate and enhance interactions in the innovation ecosystem by accelerating and catalyzing innovation activities.

Collaboration is at the core of successful innovation (Gomes et al., 2019; Lyu et al., 2023). There is an increased need for research to investigate whether and how organizations can drive innovation for sustained competitive advantage through stakeholder networks such as TH (Huggins & Thompson, 2015). Although some authors have reported successful cases (e.g., Jauhiainen & Suorsa, 2008; Ranga et al., 2008), others claim that, due to different preconditions in developing countries, TH collaborations might fail in such settings, particularly if divergent stakeholder interests are not resolved (Fogelberg & Thorpenberg, 2012). Key issues in the course of developing an innovation partnership such as TH include identifying and understanding the roles to be played by different stakeholders involved in the collaboration and, consequently, identifying and developing measures to report the performance of the collaboration in addressing local needs (Kraemer-Mbula & Wamae, 2010; Perkmann et al., 2011; Albats et al., 2017). Some studies on performance measurement in innovation networks (e.g., Cuthbertson & Piotrowicz, 2011) have suggested that to understand how a performance measurement system can be designed, built, and used, its context, process, and content must be captured.

In line with the above guidelines, it is important that the participating stakeholders' roles and responsibilities, together with their joint vision, are harnessed in order to provide grounds for measurement and evaluation (Rantala & Ukko, 2018). Measuring innovation performance is extremely important for both industry managers and policymakers. From the policymakers' point of view, timely, accurate, clear, and reliable indicators are needed to set directions and rules to stimulate a fruitful innovation environment, to select industrial sectors requiring special attention, evaluate the proposals of different applicants for innovation projects, and assess the progress of collaboration (Dziallas & Blind, 2019; Ponta et al., 2021). Measuring the performance of innovation networks is important to ensure that they achieve the status of financially and operationally sustainable businesses (Allen, 2007) and to ensure that they constantly measure progress towards their strategic goals (Davies, 2013).

However, measuring progress towards goals within an innovation network may not be a standard practice because of the diversity of stakeholders, who often have different needs and expectations (Allen, 2007; Dabrowska & de Faria, 2020). While performance frameworks exist for this purpose, most of them are mainly theoretical and generic in nature. Therefore, this study contributes to the literature by providing a framework based on empirical evidence on stakeholder roles that need to be played together with the nature of performance measures particularly suitable for TH in order to make it successful (Rantala & Ukko, 2018). Accordingly, this study seeks to answer the following research questions (RQs):

RQ1: What roles are different stakeholders expected to play to support the successful implementation of an innovation partnership like the TH model?

RQ2: What measures are important for monitoring and reporting the success of such an innovation partnership?

To answer these questions, this study draws on insights from social network theory to devise a framework for understanding the dynamics taking place within social networks and how these can lead to successful innovation collaborations. This theory is deemed suitable for informing this study because of its ability to highlight the value of social relations and the influence of different stakeholders through resource power (Bourdieu, 1986). Data were collected through semi-structured interviews with diverse stakeholders drawn from government, industry, academia, civil society organizations, and innovation hubs. The rest of the paper proceeds as follows. The next section presents a literature review on

stakeholder roles and performance measures for monitoring innovation collaborations. Thereafter, a conceptual framework based on the social network theory is discussed before presenting the research design in [Section 4](#). [Section 5](#) presents the data analysis before the discussion in [Section 6](#). The paper closes with the concluding comments.

2. Stakeholder roles and performance reporting in innovation partnerships

The literature review covers two main issues: the roles that different stakeholders play or are expected to play in successful TH collaborations and performance measures that are useful for monitoring and reporting the success of such collaborations.

2.1. Stakeholder roles that support successful TH collaborations

The definition of stakeholder roles in an innovation partnership lies in the fact that each party can do what they do best. An important prerequisite for successful collaboration is the creation and maintenance of good and timely interactions between stakeholders (Ojasalo, 2008). Caerteling et al. (2013) argue that government championship is an important positive factor in the performance of innovation partnerships because it has a greater impact than government financial/technical assistance (Marinković et al., 2016). The government is expected to provide a sustainable business environment, while universities provide the much-needed technological know-how and human resources for research centers to bring about collaborative synergies to a desired end.

Steiber and Alänge, (2013) argued that universities should play an important role in driving collaboration because they provide the foundation for breeding innovative ideas. However, the industry is expected to provide innovation funding. Ivanova and Leydesdorff (2014) concluded that stakeholder roles in TH collaboration revolved around scholarly knowledge development (for academia), wealth creation through innovation (for industry), and normative control (for the government). Houston et al. (2021) reported that universities are expected to develop and test innovation using funds from research grants. Private enterprises, through university business spin-offs or joint ventures with the private sector, engage in product marketing and commercialization. While academia continued to follow its own institutional logic in scholarly rigor, the government focused on creating a stable operating environment through policies and legislation, insisting on the need for local community engagement, as well as budget allocations (Park & Leydesdorff, 2010).

On the other hand, Mok (2012) noted that the state was responsible for devising appropriate innovation policies and building basic structures including research infrastructure. The industry's role is to identify market needs and transform research and development (R&D) outputs into profitable products. In the same vein, academia is expected to take up the role of cultivating research talent and conducting academic research and hosting incubation centers to support innovative growth. Abduljawad (2014) found the nature of the relationship between the actors to be as follows: (i) academia acted as a catalyst of knowledge and human capital creation; (ii) industry acted as a stimulator of knowledge and innovation; and (iii) the government acted as a facilitator of knowledge creation, diffusion, and protection through strategic policies and implementation (Cooke & Leydesdorff, 2006). In other instances, universities have expanded their mission to contribute to economic development through consultation with industry, joint research projects, university-based science parks, and the commercialization of innovative ideas. Correspondingly, Dekkiche (2019) observed that modern universities participate in creating a talented workforce and generating new enterprises. Researchers at universities, in addition to their mission of education, lead programs for various entities or start their own projects.

Consequently, universities are saddled with the responsibility of creating new knowledge and working with industries for the effective absorption and adaptation of internationally transferred technologies, with the government mediating between universities and industries (Fadeyi et al., 2019). Patra and Muchie (2018) argue that the role of universities is gradually being supplemented by recent developments in the concept of entrepreneurial universities. Entrepreneurial universities generate income by commercializing the technology produced in their R&D laboratories. However, the government and industry contribute funding to universities for R&D activities (Okonofua et al., 2020). In the same vein,

Mègnigbèto (2019) observed that to promote the development of the TH model, the university should not only teach and research but also compete with firms. The government should not only set up policies and regulations and collect taxes but also institute administrative bodies to conduct research or participate in generating firm capital. Industry should not only produce goods and services for the market but also conduct research on their improvement (Gachie, 2020). The foregoing literature review indicates a number of distinct and overlapping roles of stakeholders within innovation collaborations in promoting research and innovation for industrial development.

2.2. Performance measures for monitoring TH collaborations

Innovation collaboration is deemed successful if it achieves its set objectives and consequently meets or exceeds stakeholder expectations (Davies, 2013; Dabrowska & de Faria, 2020). Organizational goals, stakeholder expectations, and performance measures could be either financial or non-financial in nature. Setting performance measures for innovation partnerships, such as TH, may be problematic because they are often multi-stakeholder organizations with various entities involved in the ownership structure. Multi-stakeholder organizations have a multiple-goal nature, and their goals may change depending on the type of stakeholders involved (Defourny et al., 2006). Since a successful innovation partnership will mean something different for different stakeholders, it is difficult to assess the success or failure of these networks in a uniform way. Notwithstanding these challenges, Davies (2013) suggests that the success of an innovation network should be measured using a performance measurement system (PMS). Performance measurement is understood to be an ongoing process of monitoring how well the organization is doing in achieving its pre-established goals and objectives. It is believed that performance measurement systems (PMSs) arising from both public and private organizations have influenced the setting of performance measures for innovation partnerships such as TH. Traditional PMSs have concentrated on the development of indicators largely related to economy (inputs) and efficiency (costs) due to their limited ability to measure effectiveness or outcomes in government organizations (Marinković et al., 2016). Consequently, PMSs have increasingly become less transactional and relational to represent relationships forged along value chains and among its other stakeholders (Broadbent & Laughlin, 2009). However, as PMSs become more complex, they must consider both internal and external performance factors (Gomes et al., 2019).

Although no common approach towards performance measurement has been proposed for innovation networks, a range of generic PMSs has been developed over the last half century. These include the balanced scorecard, performance prism, smart performance pyramid, performance measurement matrix, results and determinant framework, and business excellence model (Dabrowska & de Faria, 2020). Taticchi et al. (2010) indicated that the Balance Scorecard has been the most popular performance measurement tool over the past half-century. In the same vein, Neely (2005) claims that between 30 and 60 percent of firms have adopted the Balanced Scorecard to measure the performance of innovation networks in developed countries such as the USA. However, it is argued that despite the above performance frameworks having a clear and extensive theoretical background, they do not offer ready-to-use solutions or guidelines as to how an organization should develop its own PMS. Furthermore, they do not point out exactly what and how to measure, and they do not propose guidelines for practical implementation at the operational level (Garengo et al., 2005). Most of the existing PMSs are too general in their approach, in addition to being sector-specific. It is believed that different sectors have different characteristics and contexts; therefore, different aspects of business need to be measured. Some scholars (e.g., Gomes et al., 2019) suggest that traditional PMSs may suppress innovation. Marinković et al. (2016) analyzed the performance aspect of TH and presented indicators for its measurement and monitoring. The model classifies indicators into three main categories: input indicators for planning, process indicators for organizing, and output indicators for control.

Other studies (e.g., Tijssen, 2012; Albats et al., 2017) suggested input metrics, including different stakeholders' resources allocated to the collaboration (including time, money, and staff allocated to the collaboration) and the capabilities and motivation of the stakeholders. On the other hand, output metrics involve new technologies, scientific knowledge, and skilled and trained staff. Finally, impact/outcome

metrics include new ideas, solution concepts, innovation, and human capital (Rantala & Ukko, 2018). In the face of growing challenges worldwide, such as social inequality and environmental pollution, researchers and practitioners also acknowledge the opportunity for innovation networks to address these challenges and contribute to societal well-being by creating positive social change (Kruse et al., 2023).

Fadeyi et al. (2019) indicate that the number of PhD staff employed in a university can be considered a good predictor of the overall performance of technology transfer, as this represents the human capital resource factor. At the same time, PhD students are the most important source of new employees and ideas in the research field. Patra and Muchie (2018) report that patent and publication data are used as output indicators to map the R&D activities of South African universities. Patents are broken down into collaborative and joint patents, whereas publications focus on co-authorship to reflect collaboration. The study revealed that high publishers tended to be high patentees. Others such as Okonofua et al. (2020) consider the percentage of GDP devoted to R&D funding as a legitimate measure of the government's commitment to TH's success. Șerbănică (2011) argues for funding flows and knowledge circulation as performance measures for the TH (distinguishing funding flows between grants, donations and contracts; and knowledge circulation in form of cooperation, strategic partnerships, co-publications and patent statistics as measures of success). Consequently, co-authorship has become an indicator of scientific collaboration and is widely used in academia (Sihlobo and Mbatha (2022)). The foregoing review shows that while innovation networks within developed economies appear to embrace technical and financial measures, less-developed economies seem to adopt measures of a socio-economic nature. This is an interesting position in the literature considering that different types of innovation collaborations exist for different purposes. Accordingly, there is a pressing need to investigate how theoretical models, such as TH, can be tailored to match the innovation needs of society in an emerging economic context (Striteska & Spickova, 2012).

3. Theoretical framework for innovation collaborations

The conceptual framework embraced in this study draws on ideas from the social network theory (SNT), which originated from mathematical graph theory. SNT has been applied in many disciplines (Otte & Rousseau, 2002) and research domains, including social mobility, social stratification, policy networks, elites and power, healthcare, professional interactions, and scientific collaborations (Lucas & Mayne, 2013; Tasselli, 2014; Patra & Muchie, 2018; Guven-Uslu, 2017; Phiri & Guven-Uslu, 2019). The term 'network' refers to a set of nodes and relationships that connect actors (Ojasalo, 2008). A network can be viewed in terms of its activities, resources, and actors (Hakansson & Snehota, 1995). Activities and resources in two different relationships can complement each other or compete. Similarly, actors can use complementarity or competitiveness in their relationships in different ways when interacting.

In a scientific collaboration network, nodes represent authors/partners and ties (links) that reflect co-authorship relations and co-generated ideas among them (Abbasi et al., 2012). While SNT has the ability to provide mathematical measures, such as centrality, density, and path lengths, the theory is equally useful within critical/interpretivist research traditions to understand the interdependent characteristics and activities between individuals, groups, and organizations (Güven-Uslu, 2017; Phiri & Guven-Uslu, 2019). In networks, an innovation should not be seen as the product of one actor but as a result of the interplay between several actors. By focusing on the social links between people, SNT enriches the analysis of society based on the sociodemographic and economic attributes of individual actors, groups, and external structures (Lucas & Mayne, 2013).

Three key concepts underpin the application of SNT in interpretative research: centrality, density, and brokerage. Centrality is a fundamental concept in SNT for identifying prominent actors in a network. Centrality indicates the importance or influence of actors (Freeman, 1979; Borgatti & Everett, 2006; Borgatti, 2005) as dictated by the amount of power or resources possessed by an individual, group, or organization within network arrangements. Centrality encompasses the idea of popularity or access to resources as manifested by the actor who has the most connections with other actors (such as C in Figure 1). Centrality is determined by capital owned and accumulated by an individual actor, group, or organization. Examples of such symbolic and financial capital include policy formulation, regulation and financing collaborations.

Bourdieu (1986) perceives this capital as any resource effective in a given social setting that enables one to appropriate specific benefits and participation and acquire positions in society. Capital may also be regarded in terms of the economic, cultural, social, and symbolic resources accumulated by individuals and groups of actors as they vie for influence in institutional processes. On the other hand, network density is a measure of the number of actual or observed connections between actors compared with the maximum possible number of connections that could exist between the actors (Burt, 2000). In Figure 1, for instance, E is connected to one member (C) out of a possible total of four members in the network. Therefore, the density of E is one out of four ($\frac{1}{4}$). Network density shows the strength of ties between individuals, groups, and organizations involved in collaboration. In this study, density is reflected by the actual collaborations each stakeholder has with the other three including intermediating organisations. Finally, brokerage entails the extent to which the focal actor (such as E and F in Figure 1) spans other actors who are not connected with each other (Tasselli, 2014; Avina-Vazquez & Uddin, 2016). These key actors are often responsible for playing an intermediary role in bridging structural holes or communication gaps that may exist between networks in order to facilitate the flow of information and resources between networks while gaining their own advantages from the transaction (Burt, 2000, 2004; Goyal & Vega-Redondo, 2007; Guven-Uslu, 2017). These actors are critical within innovation collaborations because they help to link organizations that may not be speaking to each other but are critical to the success of the collaboration.

An example is the role of incubation hubs, civil society, and faith-based organizations that often help to facilitate and catalyse interactions between government, academia, and industry stakeholders to ensure that ideas on innovation and economic development are shared and harnessed.

TH is a network of collaborations between the government, industry, universities, and research institutions aimed at generating useful knowledge and enhancing prospects for the development of innovation capabilities. Collaboration through networking is viewed as a means of facilitating learning and the transfer of technology and innovation (Van Dijk & Sandee, 2002). Accordingly, the TH model of innovation is often described as embedded in social relationships that occur as a result of geographical concentration and proximity (Doloreux & Parto, 2004). Lin (2001) suggests that the value of social capital propagated by Bourdieu (1986) can be captured in two main dimensions that are relevant to the successful operationalization of a TH model. First, social capital facilitates information flow and knowledge sharing among the actors. Second, social relations are instrumental in reinforcing group identity and recognition which fosters informal norms, trust, and strong ties within the group. Putnam (2000) and Coleman (1990) claim that a social network with strong ties and densely interconnected players leads to higher social capital formation. Social networks have the potential to influence learning processes, provide opportunities for problem solving, and establish new ideas. Thus, they can foster synergistic effects, bring together key resources, such as the know-how of participating actors, and promote innovation diffusion (Kolleck, 2013). Although social capital often focuses on its positive aspects, there are drawbacks associated with its use in managing TH relationships. For example, social capital that leads to social cohesiveness can also lead to suspicion and distrust of outsiders in the group or network. This can

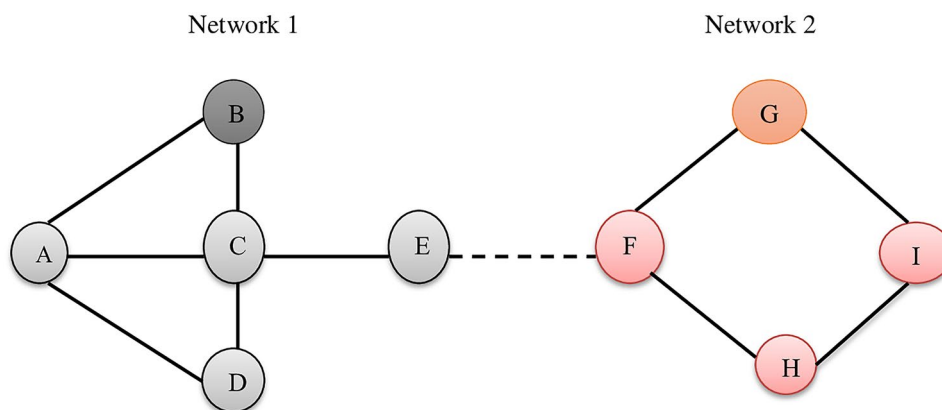


Figure 1. Social networks centrality and brokerage (adopted from Phiri and Guven-Uslu, 2019).

adversely affect the effectiveness of collaboration (Fine, 2001). It can also impact the degree and ability of a group and its members to be transparent and accommodate new ideas and approaches. Thus, trust is a key aspect in the effective functioning of social networks.

4. Research methods

To respond to the paper's research questions, a qualitative and interpretative study design was used to emphasize the meanings that different stakeholders attached to TH within their social context. Qualitative research was deemed useful for providing an in-depth perspective to describe and interpret the meaning of TH to different stakeholders within their context (Cooper & Schindler, 2014). These meanings helped to unravel the value of TH to different stakeholders in terms of its value for enhancing research, innovation, and entrepreneurial development, ultimately leading to job creation and economic development. Qualitative data collection relied on primary sources in the form of personal interviews with various stakeholders from industry associations, government ministries and agencies, and academic and research institutions. Prior to the commencement of data collection, the study was approved by the Copperbelt University Social Science Research Ethics Committee in January 2022. Data were collected between February and October 2022. Interviews were also conducted with respondents from various industry and professional institutions, including the Zambia Chamber of Commerce and Industry, Zambia Chamber of Mines, Zambia Association of Manufacturers, Engineering Institute of Zambia, Economics Association of Zambia, and Zambia Institute of Marketing. Others included the Zambia Institute of Human Resource Management, Zambia Institute of Purchasing and Supply, Zambia Institute of Chartered Accountants, entrepreneurial and incubation hubs, universities and research institutions, and civil society organizations involved in research and innovation services.

In line with SNT, the interview questionnaire contained different sections with questions investigating diverse matters including the nature of previous and current collaborations, factors considered critical for the successful implementation of TH collaborations, the influential roles of different stakeholders within successful collaborations (Freeman, 1979; Borgatti & Everett, 2006; Borgatti, 2005), and performance measures used for monitoring the success of TH collaborations. These questions ensured that respondents engaged in conversations that provided critical insights into the study's research questions. An initial sample size of 30 was targeted for the study, and 32 interviews were actually conducted. The distribution of the respondents is presented in Table 1. Informed verbal consent for participation in the study was obtained from individual respondents. Interviews were subsequently conducted and digitally recorded after which audios were transcribed to enable the researcher revisit these during data analysis. After repeated readings, the transcripts were coded to identify similarities and differences in the patterns of perspectives from different respondents. Qualitative data analysis involved thematic analysis (Braun & Clarke, 2006) to identify the key themes emerging from the data, which were guided by the different stakeholder roles and performance measures identified by respondents. A combination of top-down and bottom-up approaches to coding was used, whereby theoretically informed codes were created beforehand and applied to the text (a priori coding), but emergent coding was equally used where codes were drawn from the interview transcript text (Blair, 2015). A number of codes were generated including the centrality and brokerage roles of the government, academia, industry, the nature of previous and current collaborations, and performance measures used for monitoring the performance of their TH collaborations (Avina-Vazquez & Uddin, 2016). These codes were subsequently summarised and refined to ensure that they fitted within the main themes gleaned from the data. The final list of

Table 1. Distribution of interview respondents

Category of Respondent	Number of Interviews	Position
Government ministries and agencies	10	Director
Industry (including industry associations)	11	Director
Academia (including research institutions)	8	Dean, Director, Head of Department
Intermediating organisations (including incubation hubs, civil society and faith-based organisations)	3	Director, Manager
TOTAL	32	

codes (appendix 1) was synthesised and summarised into key themes to depict the key stakeholder roles related to the implementation of the TH and measures used for monitoring these collaborations.

5. Research findings

The findings below are based on the two main issues investigated in this study: the roles and influence of stakeholders in supporting successful collaborations and performance measures useful for monitoring the effectiveness of these collaborations.

5.1. Stakeholder roles and influence in TH collaborations

The objective of ascertaining the roles of different stakeholder groups to support the successful implementation of the TH in Zambia was explored through a careful reading of data transcripts to ascertain the content of each interview. In line with the theoretical framework, the findings of this study are as follows:

5.1.1. Government as a broker of collaboration and provider of financial capital

Interviews revealed specific brokerage and centrality roles required for the government, including providing financial resources, and setting the policy direction and an incentive framework to promote and catalyse collaborations. The brokerage and centrality roles indicate that the government is expected to influence collaborations through driving and coordinating the national agenda on research and innovation, investing in research infrastructure by academia, facilitating commercialization and entrepreneurship, and creating mechanisms for industry and academia to interact regularly around research outputs, needs, and best practices (Borgatti & Everett, 2006; Tasselli, 2014). A representative of an industry association commented on the need for a policy framework.

First, I think policy has to be there, we are hoping for a policy and legislation that will be aimed towards joint ventures and partnerships between the big ones and the smaller companies [...], technology needs to trickle into the industry, specifically SMEs [...].

A government innovation expert suggested that intellectual property (IP) policies and legislation were needed to strengthen the innovation framework, clarify IP ownership, and promote the research and commercialization of government-funded research output. The expert explained this centrality role expected from the government:

I think what Americans did, and what South Africans borrowed from there is really good [...], clarifying ownership of public funded research and also allowing universities and industry to commercialise research output as long as the country benefits [...]. Zambia needs to do that too [...], we have a weak policy framework. [...]. There must be strong awareness by all these parties of what this triple helix model is and how it works. I think funding has been the biggest challenge.

In line with its brokerage role, the government is expected to clarify mutual benefits, develop research and innovation capacity, and develop trust for smooth co-creation between industry and academia. This brokerage role was clarified by an officer from the innovation hub.

For these collaborations to really work there should be some kind of a win-win scenario [...], as in what would make the academia interested in such a collaboration. What would make the government interested in such a collaboration? What would make the industry interested in such a collaboration?

Consistent with the brokerage role, respondents elaborated the need to have a national coordinating agency for the entire national innovation and research ecosystem. The provision of a conducive collaboration space through the creation of a unit/body to drive collaboration between entities in the TH model is reiterated here. A director from the research institution explained:

There is no one really driving the agenda of innovation nationally or in industry [...], it's almost like industry is each one on his/her own, hence limited opportunities for transfer of knowledge between academia and industry.

Accordingly, the government was urged to facilitate capacity-building for technology and innovation support centers (TISCs) to enhance the functioning of the TH model in Zambia, reinforcing the centrality of government in innovation networks. An innovation and IP support officer provides the following views:

The idea was originally to start here supported by WIPO [World Intellectual Property Organisation] and then we grow them into other institutions such as universities to be able to support researchers in the use of patent databases as part of literature review to avoid reinventing the wheel.

An officer from the Ministry of Agriculture reiterated how the government, in its centrality and brokerage roles, had helped provide critical information, as a form of social capital, to innovation collaborations to improve beneficial outcomes. He provided an example of the work done by the ministry:

We have been collaborating with the meteorological department to issue agro-meteorological bulletins where the meteorological department issues a forecast. And then there is an advisory part of it to tell the farmers that looking at the soil conditions at this time, this is the right time for them to plant. Sometimes even to advise farmers that looking at the weather conditions, if there's a dry spell we would advise farmers not to weed their fields.

Another officer from the Ministry of Agriculture stated that her department provided training to farmers, in addition to other technologies. This social capital provides important platforms for learning and development to harness agricultural processes.

We have farmer training centres that fall under extension services. Those centres are designed to showcase different technologies that can lead to increased production and productivity for the farmers. That's how we collaborate with most of NGOs. Then we have to work together to take that technology down to the farmer who is in need of it.

The above accounts demonstrate the centrality and brokerage roles of the government in ensuring that TH collaborations are enhanced. This facilitation is expected to take place by providing policy guidelines, a conducive operating environment for stakeholders, incentivizing participants in the innovation ecosystem, and providing critical information useful for catalyzing innovation activities.

5.1.2. Academia as a provider of social and symbolic capital

Key roles identified for academia as a source of social and symbolic capital include developing mechanisms for regularly identifying R&D needs in industry; generating, developing, and adapting relevant technologies; developing expertise and research infrastructure for diverse R&D areas; and testing the efficacy of new technologies (Bourdieu, 1986). For example, regarding the identification of industry needs, a research officer at an agricultural research institute explained that academia needs to meet the technological needs of farming systems:

We also look at the farming systems, farmers' activities [...], what are the social and economic factors that they are faced with so that we look at improving their livelihoods [...]. Ensuring household food security, income security, and nutrition security through new technologies.

In its training portfolio, academia is also expected to collaborate with the industry through internships to produce industry-ready graduates. One respondent from an industry association explained that the current collaboration situation was characterised by low levels of collaboration, depicting the low network density (Burt, 2000).

Academia is not responsive to industry needs or even to just sign an MOU. I think the reason for wanting the MOU was skills development so for us to have students have easy access to industry through internships [...], a proper platform where all players can engage also plays a critical role.

A manager at an intermediating organization argued that academia should engage industry and increase the level of collaborations in order to generate and implement fresh ideas for long- and medium-term competitiveness and growth:

We wanted to have something like concrete ideas [...], not only long term but also getting fresh ideas from the student teams either to existing products or products nearly on the market. The needs of academia and the needs of industry can be met [...] because what we have come to see in our interactions is that we know very little about the other, very little.

In reinforcing the position of academia as a provider of social capital, a manager of business promotions explained that academia is expected to generate knowledge through research activities, and that this knowledge should trickle down to industry and society at large.

We work closely with academia where we are able to channel the knowledge that is generated within the academic realm directly into business. I think that is the missing link; we have a lot of research that is conducted within universities but unfortunately this is not trickled into business and society.

In addition to their brokerage role, academic institutions have also been reported to provide platforms for knowledge sharing and exchange programmes. A head of research at a private university explained that his university has been undertaking not only research activities but also knowledge-sharing activities with collaborators:

Most of the collaborations that we are desiring to go into, the key target is joint research, joint research applications with those collaborating partners. The other one focuses on the issues of, especially with international collaborators, student exchange programs [...], then locally we have issues to do with internships.

These findings demonstrate the centrality roles of academia in terms of creating knowledge and technologies that should be able to address the problems faced by industry and society in general. This knowledge creation is likely to be enhanced through collaboration with industry and other stakeholders in the course of research, development, and knowledge sharing.

5.1.3. Industry as a provider of financial and social capital

The centrality role of industry has been portrayed through depicting industry as the epicenter of the commercialization of knowledge generated by academia to make it commercially useful. For this commercialization to thrive, there is a need to promote interactions among stakeholders, especially in terms of sharing the benefits of innovations. This centrality and brokerage role by industry was argued by an officer from a research institute.

We have been collaborating with industry partners for some time now [...], that is the only way we could have our [seed] varieties commercialised. So we had an MOU [...], the percentages [of royalties] on the MOU were 5% of revenue [...].

A Chief Executive Officer (CEO) of an entrepreneurship hub explained that his organization received technical support, as a form of social capital, from corporate organizations to enhance their innovation support activities. This support came in the form of Internet connectivity and legal and accounting advice to start-ups supported by the hub.

So Liquid [Telecoms] provide us with internet. In return they want to see more startups leveraging their infrastructure [...], we have partnerships with law firms and they are able to provide legal advice to the startups. PWC [Price Waterhouse Coopers] then came in to provide the usual accounting tax advisory.

In addition to these business support services, the CEO reiterated that industry partners demonstrate their influence through providing financial resources to start-ups.

We identify the partners based on the opportunities or needs of our entrepreneurs or the work we do and in some cases the partners themselves identify particular opportunities and then put in their money.

Another type of economic capital reflecting the centrality role of industry is depicted through creating a network of business angels that helps to provide a readily available pool of capital for start-ups to support collaboration. The CEO added:

The Zambia Business Angel Network now have a website called <https://zban.org.zm>, they have a process where they vet people who are pitching ideas [...], there is an application form on the website. We actually had one [pitching] a month ago.

Industry stakeholders are also reported to provide training to their members on specific aspects of the industry, such as compliance with government regulations, policies, and other laws, as a way of making them more competitive. The CEO of the Association of Manufacturers explained the nature of this symbolic capital:

We provide training to our members for them to understand certain regulations in the sector, how they can be compliant in their operations, as well [as] make their product competitive against imports or against the standards that they need to comply with.

Partners from industry equally provide social capital in the form of business linkages to their members to enhance their market access and competitiveness. The CEO added:

Aside from the training, we do business linkages like I mentioned earlier, so we identify a market for our members, for example, we help them to get into chain stores like Shoprite, Choppies, PicknPay [...].

These findings show that the centrality and brokerage roles played by industry include the provision of social and economic capital by developing and sustaining a culture of continuous improvement, innovation around new products, new services, and new processes and methods to meet the evolving needs of customers. Additionally, industry is expected to provide room for internships with university students, who help generate fresh ideas for medium-to long-term competitiveness. Industry is also expected to fund the commercialization of output from such collaborations with academia. In other circumstances, it has been shown that specific roles are performed jointly between two or more partners. However, there are not many collaborations between the triple helix partners, indicating the low density of the relationships. In line with SNT, such roles require trust between the stakeholders in order for the collaboration to thrive.

5.2. Performance measures for monitoring TH collaborations

Respondents were asked to explain the performance measures that they used to determine the success of their current collaborations and which they thought would be useful in informing interventions that build and sustain partnerships between government, industry, and academia. Performance measures have been identified to fall into three main categories: socio-economic measures, measures of knowledge and human skills, and measures of innovation outcomes.

5.2.1. Measures of socio-economic performance

These measures reflect the extent to which social and economic capital is generated by collaboration. One of the key socioeconomic measures reflects the extent to which industry and societal problems are resolved using ideas arising from collaboration. It is argued that by scaling up start-up businesses, more jobs should be created and more revenue should be generated, leading to an increase in the tax paid by businesses created by the collaboration. The technology manager argued that:

So you can measure [the success] by looking at how you have solved the problem for the industry. The government will be looking if the industry has grown because of these solutions, how much it has contributed to employment, how much it has contributed to tax. So there has to be a problem which you have solved.

Another important performance measure mentioned by the respondents was the number of memoranda of understanding (MOUs) to reflect the strength and density of collaborations. However, this measure was cautiously mentioned, and a number of respondents explained that this should not simply mean the number of MOUs signed, but those MOUs that have been activated and produce the desired outputs. For example, a CEO of an incubation hub explained that while CEOs have created a push for visually appealing collaborations by signing MOUs, there is a need to ensure that these MOUs are actualized.

There is a push to create collaborations that are visually appealing [...], where people sign an MOU then one year later [there is] nothing. MOUs are a KPI [key performance indicator] for most organisations particularly for CEOs. A CEO will sign the paper and they will be busy in meetings. [But] As long as the CEO is very involved in the mechanics of the MOU and sets up KPIs for their staff and they are engaged then it works [...].

This position was reinforced by the head of research from an academic institution who reiterated that MOUs need to be actualized because simply signing the paper and doing nothing thereafter makes no difference.

The collaboration should not just end with signing MOUs, because when you sign MOUs then you need to actualise those MOUs. Because there is the issue where you sign MOUs and then you have no people to actualise those MOUs.

A CEO managing an agricultural policy institution narrated that his organization's goal was to eliminate malnutrition and poverty, and ultimately contribute to economic growth through the effective implementation of national development plans.

For the work we do, our vision is to have a Zambia where there is no malnutrition, there is no poverty [...]. So with regard to these collaborations, and I think you know even in the national development plans, the goal is economic growth and eventually reduce poverty levels.

A principal mine inspector explained that the collaborations his organization had entered into prioritized environmental sustainability in terms of reducing the amount of sulfur dioxide emitted into the atmosphere.

[...] a reduction of emissions of sulphur dioxide emissions into the atmosphere because like now [...] those have reduced so much because like in Mufulira [...] they've reduced by over 97% [...].

The above findings show that the benefits arising from innovation collaborations need to meet the socioeconomic needs of society and thereby improve the quality of life of communities.

This is an important dimension of such solutions to demonstrate that the ideas generated by innovation collaboration trickle down to the lowest echelons in society.

5.2.2. Measures of social and symbolic performance

These measures reflect the extent to which social capital is created through collaborations. For collaborations involving education and training programs, it was indicated that there was a need to look at the number of graduates coming out of these programs and what impact they were creating in industry and society. A director of the government ministry explained:

Like the World Bank project at the Africa Centre of Excellence, we have to see how many graduates have come out of this project, where they are working and what impact they are giving to the areas where they are working [...].

This position was supported by the head of research from an academic institution who explained that collaborations need to equally focus on the number of interns being trained and supported in preparation for taking up positions in industry and government. A number of such collaborations also involve student exchange programs to expose students to different learning environments.

There are some collaborations that we have locally with industries [...], especially the banks. We have MOUs with the banks [...], opportunities for students who do internships [...], opportunities to do research and then also to provide in-house training for staff that are working in those respective organisations [...], joint research applications, student exchange programs especially with international collaborators [...].

Another respondent from an academic institution indicated that innovations should not only be theoretical innovations from academia but should also be practical solutions capable of meeting the needs of industry and society at large.

The other thing is to look at the innovations that come out from the university into society or into industry, how many are these? And these innovations should probably be measured at two levels; how many innovations have come out from these universities? How many of these have actually reached the market? Because you can produce something in the academic circles but it may not be valuable for the industry.

An officer from a government agency dealing with the registration of companies and intellectual property rights (IPRs) explained that their success is measured by the number of IPRs registered in terms of patents and trademarks.

In terms of [our] performance [...], if you look at our mandate, it's quite clear [...], enactment of laws, awareness and sensitisation. The other one is promoting innovation and creativity [...], for us it's the numbers.

Within academia, performance measures focusing on research inputs and outputs, such as funding from joint research applications and publications, have been suggested as suitable for assessing the effectiveness of collaborations. The head of the research from an academic institution stated:

If the core mandate for that collaboration is the issue of making joint applications, we will look at how many applications they have made, and how many have been successful [...].

This position was reinforced by a director of research from a different institution who added that publications have been a traditional measure of performance within academia to indicate the level of activity of a university:

From time immemorial, publications are very important. The university's performance is measured according to the number of publications, it's one of the measurements of how active the university is. So actually, even most of these funders specify how many publications should come out of the funded research.

These findings reiterate the need for academia to generate knowledge and innovations, as a form of social capital, that can address the needs of industry and society. While academic outputs such as publications are useful measures of academic performance, it is important that they should be based on ideas that can be commercialized into business products and services capable of generating income, or ideas capable of solving problems faced by industry and society at large.

5.2.3. Measures of financial and social performance

These measures reflect the extent to which social and financial capital is generated by innovation collaborations through diverse centrality and brokerage stakeholder roles. One of the most cited performance measures within this category is the number of innovations. A supervisor of environmental management in the mining sector explained that these are not just theoretical innovations, but innovations that are capable of generating income and creating employment:

One way we can measure the success of the collaboration is by looking at the number of innovations coming out of the partnership [...], innovations that can generate income and create employment for the youths.

Another respondent was of the view that these innovations should reflect local products and services in the market that arise from the commercialization of outputs through collaboration among the three stakeholder groups. A director from a research institution has argued that:

I think we need to see more local innovations in the market. These could be products or services that come as a result of collaborations [...], commercialisation of outputs from these collaborations.

With respect to the number of innovations coming out of the collaborations, the CEO of an incubation hub argued that an alternative way to measure the success of collaborations was to look at the number of start-ups created and how they have been scaled up. It was argued that collaboration generates revenue and creates employment only by scaling up such start-ups.

What we look out for at the end of the program are different KPIs depending on the program that we are doing. It could be growth of businesses or number of key businesses created, revenue [generated], staff employed [...], tax contributed to the government.

In some ways we can go very deep in finding out different metrics. And those can vary from program to program but ultimately, we want businesses themselves to grow.

To promote local innovations, an officer from a patent registration office reiterated that in the recent past, the focus of his office had shifted to look at local registration of IPRs to change the pattern from these being dominated by foreign applications.

Because in terms of patents, even up to now, the majority of patents are still foreign applications. We get very minimal numbers for Zambian patents. Then we've noticed a significant rise in the numbers of trademarks for locals.

It is evident from the above that the performance measures involve the whole spectrum of inputs, outputs, outcomes, and impacts at different levels of society and in different sectors of the economy.

Based on these findings, it appears that organizations seeking to collaborate using the TH model should identify key outputs in the form of visible innovations, businesses created, quantification of income generated, and number of jobs created.

6. Discussion of findings

The discussion presented below is based on the above findings and is in line with the theoretical framework used for the study. The foregoing findings were synthesized, as shown in [Figure 2](#), to reflect the network of relationships, activities, and responsibilities of different stakeholders and the performance measures used for monitoring the effectiveness of these collaborations.

6.1. Stakeholder roles and influence on innovation partnerships

These findings indicate that different stakeholders play different roles in promoting the success of TH collaborations. Consistent with SNT, these roles are determined by the capabilities and resources of specific stakeholders to depict their influence on collaborations as a reflection of their centrality in the collaboration (Borgatti & Everett, 2006; Borgatti, 2005). The findings show that, as a broker of collaborations and provider of financial capital, the government is expected to facilitate and support collaborations by providing a conducive environment through legislation, policy formulation, and regulation. In doing so, the government is expected to communicate national strategic priorities for research and innovation, coordinate and fund annual innovation events, provide tax incentives to innovators, and craft appropriate legislation and policies to promote innovative collaboration. While providing social capital and playing a brokerage role, the government is expected to enhance policies that promote industry-university research/innovation activities and create and support innovation intermediaries such as innovation hubs (Ivanova & Leydesdorff, 2014).

In another dimension, the government is expected to provide financial capital by allocating research, innovation, commercialization, and entrepreneurship funding. On the other hand, as a provider of financial and social capital in its centrality role, industry is expected to embrace a culture of continuous improvement and innovation in order to develop products and services that meet the needs of the market and society in general, commercialize beneficial research/innovation output, and pay appropriate royalties for licensed technologies from universities and research institutions. Finally, universities, as providers of social and symbolic capital in fulfilling their centrality role, should build research infrastructure to develop technologies needed in industry; build research infrastructure for testing relevant technologies; generate, develop, and adapt relevant technologies for use in industry; and implement mechanisms to regularly engage with and identify innovation and R&D needs in industry (Houston et al., 2021). Universities are also expected to disseminate their research and innovation activities by publishing their work in international top-tier journals and in popular dissemination channels for the benefit of society beyond academia. The study concludes that the government, as a key broker of TH collaborations (Tasselli, 2014; Avina-Vazquez & Uddin, 2016), should facilitate the creation of a conducive environment in which industry and academia will closely interact through joint research and innovation ventures. Within this collaborative space, the industry is expected to provide research and innovation funding, while academia engages in actual research activities. While the industry provides advanced innovation funding, the government is expected to provide early research or seed funding which is rarely provided by industry stakeholders. Through such collaborations, the industry is expected to become the center of innovation by engaging academia that should promote technology development and entrepreneurship. The government is also required to play a brokerage role in ensuring that the progress of these collaborations is constantly monitored using performance measures (discussed below) to enhance innovation activities and outcomes.

6.2. Performance measures for monitoring innovation partnerships

The study's findings presented three main categories of performance measures for synthesis purposes. The first category is an increase in socio-economic capital (consisting of signed and activated MOUs; increase

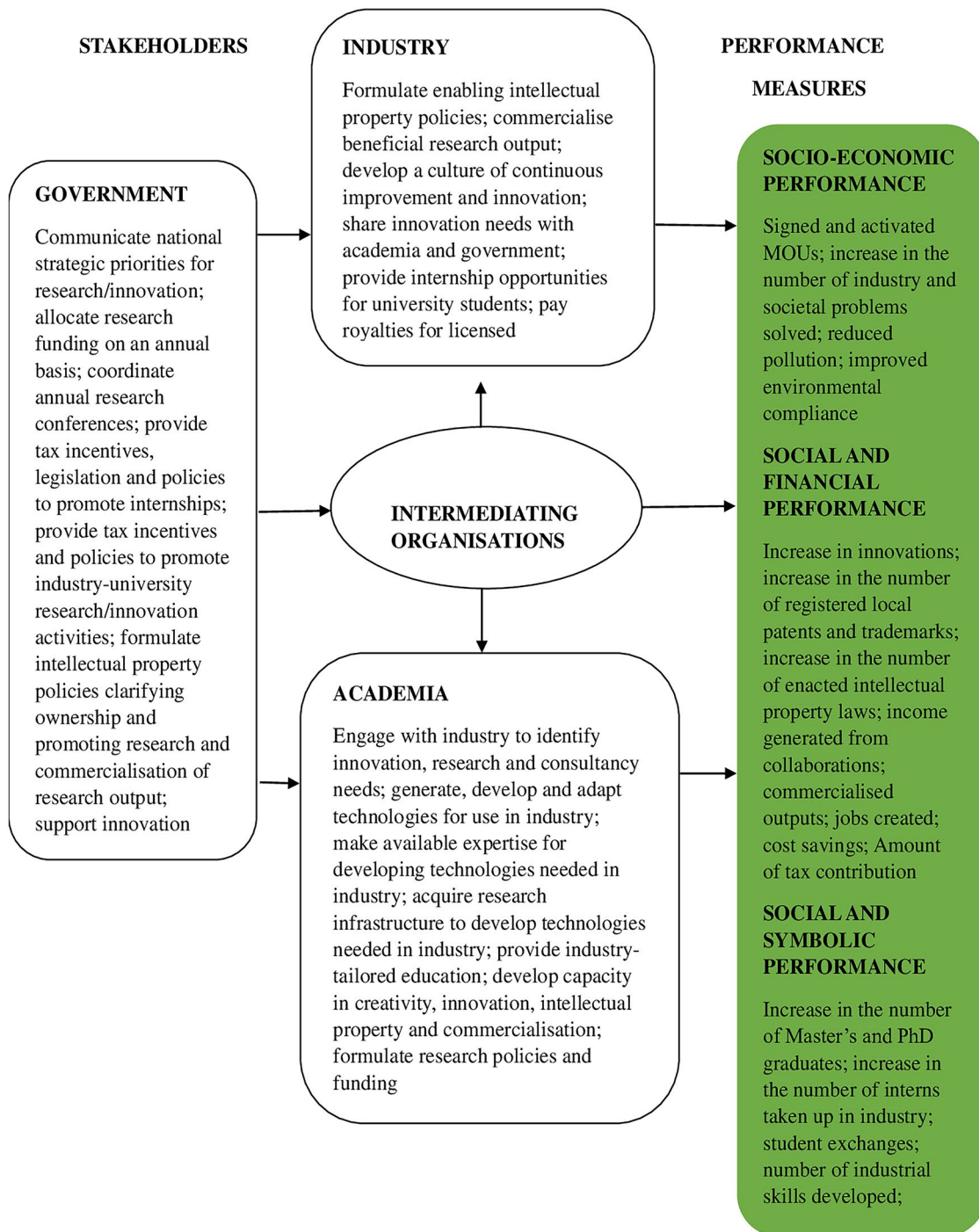


Figure 2. Data-driven triple helix model.

in the number of industry and societal problems solved; reduced pollution; improved environmental compliance). The second category is an increase in financial and social capital (increase in innovations; increase in the number of registered local patents and trademarks; increase in the number of enacted intellectual property laws; income generated from collaborations; commercialised outputs; jobs created; cost savings; amount of tax contribution). Finally, an increase in social and symbolic capital (Bourdieu, 1986) comprises an increase in the number of master's and PhD graduates; increase in the number of internships taken up in industry; student exchanges; and the number of industrial skills developed. It is important to note that these measures appear to be determined by the centrality roles played by different stakeholders within the TH collaborations. Regarding the first category of measures, it was observed that while these measures

were deemed suitable for monitoring innovation partnerships in a developing country context, they did not demonstrate good harmony with practices from developed countries.

While the measures reported from developed contexts reflect the technical and industrial dimensions of innovations, the socioeconomic measures included under this component focus on the social and economic needs of society. This position indicates that whereas the developed economic context appears to focus on industrial development, the developing context takes a more social focus in its emphasis. In contrast, the literature from less developed countries bears similarities with the performance measures reported by the respondents in this study. Socio-economic measures equally reflect the extent to which innovation and research in the TH address societal and environmental challenges, as well as market and commercial needs (Salim, 2017; Houston et al., 2021). For instance, the measures indicated above are consistent with the position reported by Fadeyi et al. (2019) who argued that the number of employed PhD staff in a university can be considered a good predictor of overall performance in technology transfer, as this represents the human capital resource factor. In contrast, the failure to embrace research publications by the current study contradicts the position taken by Patra and Muchie (2018), who report that patent and publication data have been used as output indicators to map the R&D activities of South African universities. This position is of concern, especially considering that high publishers tend to be patentees. Regarding an increase in social and financial capital, the measures included under this component resonated very well with reported practices from both developed and less-developed contexts (Patra & Muchie, 2018). This similarity with different geographic regions points to the cross-cutting nature of the suitability of these performance measures for monitoring the success of innovation partnerships such as the TH. Performance measures categorized as 'an increase in social and symbolic capital' are highly reported in regions where performance measures dealing with creativity and skills such as leadership, involvement and support, and designing organizational innovation strategies have been adopted (Salim, 2017). Therefore, efforts need to be escalated to generate knowledge and skills that promote innovation and entrepreneurship to create new products and services. Through such efforts, new business enterprises can be created with the hope of creating jobs and generating revenue. These indicators are able to reflect the significant results of innovation realized from any TH collaboration, as they translate into socio-economic benefits for the general population.

7. Concluding comments

Consistent with SNT, this study demonstrates that different stakeholders play different centrality and brokerage roles within TH collaborations. While the centrality roles of all stakeholders appear to be well executed, the foregoing findings indicate poor levels of brokerage activity by the government and other stakeholders. This position is equally true regarding the levels of collaboration to reflect the density of collaborations. Government policy for enhancing and catalysing TH collaborations, together with other facilitatory and coordinating roles, still need to be streamlined in order to get the desired results from TH collaborations. Based on the observed low collaboration density and brokerage activities, these findings conclude and recommend for concerted efforts among the government, academia, industry, and intermediating organisations to deliberately enhance the innovation ecosystem in Zambia.

First, there is a need to continuously strengthen the education system at all levels in order to promote and emphasize hands-on science, mathematics, innovation, and the commercialization of intellectual property and entrepreneurship. Second, scientific research and development for product, service, and process development need to be promoted and supported by developing mechanisms for academia and industry to regularly interact and share knowledge for solving industry problems. Specialized research centers, innovation hubs, or technology and innovation support centres TISCs around national priorities and strategic areas/sectors could be opened and funded in selected universities and research institutions. Third, it is imperative to promote the registration, protection, and utilization of intellectual property through technology transfer offices and research activities. Finally, there is a need to increase research funding by targeting a certain percentage of the annual budget (Okonofua et al., 2020). Such a position will increase the level of collaboration activity in the country and boost the current low levels of brokerage activities and the density of collaborations. For the performance measurement system recommended above to be effective, there is a need for the government to broker an environment where industry and

academia will interact closely with each other. This could be achieved by promoting joint research and innovation ventures where the government provides seed funding, industry provides advanced research funding and universities undertake such research activities on behalf of industry partners. Alternatively, industries could jointly undertake research/innovation activities with universities in addition to providing research and innovation funding. Such close interactions will also ensure that industry needs are quickly identified and adopted through university curricula in response to industry requests. In all of these arrangements, the government is expected to play an ever-increasing brokerage role in ensuring that the progress of these collaborations is constantly monitored through the highlighted performance measures (Rantala & Ukko, 2018). This brokerage role can be enhanced through the involvement of intermediating organizations such as innovation hubs and civil society organizations that could play a critical role of promoting and catalyzing interactions between TH stakeholders.

Therefore, this study contributes to the literature by providing empirical evidence on stakeholder roles and the nature of performance measures suitable for innovation networks such as the TH (Rantala & Ukko, 2018; Dziallas & Blind, 2019; Ponta et al., 2021), particularly from a SNT perspective in an emerging economy context. The study demonstrates that, contrary to practices in developed country contexts where innovation is based on technical and scientific outcomes, innovation networks within developing country contexts appear to focus on outputs and outcomes of a socioeconomic nature. In view of this finding, the study recommends that reasonable resources should be committed by the government and industry to enhance collaborations that should generate socioeconomic outcomes such as job creation, income-generating opportunities for the youth, and environmental protection in view of the effects of climate change. The study equally demonstrates that in order to increase the levels of collaboration activity (collaboration density), there is a need for the government to escalate its centrality and brokerage roles to ensure that a conducive environment is created where academia and industry can constantly interact and share knowledge on how to solve industry and societal problems. A subsequent study could attempt to undertake a comparative analysis of two or more developing country contexts to enhance our understanding of the intra-region, intra-continent, inter-region, or inter-continent differences and factors that help explain these variations.

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Data availability statement

The data and materials supporting this work can be accessed on request through the following email address: jmphiri72@yahoo.co.uk

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Appendix 1: Coding structure

Coding for stakeholder roles on centrality and brokerage

Government as a broker of collaboration and provider of financial and social capital

- Communicate priorities for research, innovation and entrepreneurship
- Coordinate annual research conferences
- Allocate funding for research, innovation and commercialisation
- Create national strategic research centres
- Provide tax incentives to industry to promote internship
- Provide tax incentives to promote industry-university collaboration
- Formulate intellectual property policies to clarify ownership
- Support and promote innovation intermediaries

Academia as a provider of social and symbolic capital

- Provide mechanisms for engaging in research, innovation and consultancy
- Generate, develop and adapt relevant technologies for use in industry
- Provide expertise for developing technologies needed in industry
- Create research infrastructure to develop and test technologies needed in industry
- Formulate intellectual property policies for research and income generation
- Provide industry-tailored education in consultation with industry
- Develop staff capacity in research, innovation, and intellectual property
- Develop mechanisms to respond to needs for consultancy, research, and innovation

Industry as a provider of financial and social capital

- Formulate enabling intellectual property policies
 - Commercialise beneficial research/consultancy output
 - Develop a culture of continuous improvement to meet customer needs
 - Pay appropriate royalties for licensed technologies from research institutions
 - Share innovation needs with universities and government
 - Provide internship opportunities for university students

Coding for performance measures

Measures of socio-economic performance

- Number of industry and society problems solved
 - Number of MOUs signed and activated
 - Promote food security in society
 - Poverty reduction in communities
 - Reduce the amount of toxic carbon emissions
 - Reduced number of accidents in workplaces

Measures of social and symbolic performance

- Number and quality of graduates from universities
 - Number of internships with local industry
 - Number of local and international student exchanges
 - Number of innovations
 - Number of intellectual property laws enacted
 - Number of publications
 - Number of research products
 - Number of skills developed and improved

Measures of financial and social performance

- Commercialised outputs and intellectual property rights
 - Number of innovations that generate income
 - Amount of income generated from the collaboration
 - Number of businesses created and scaled up
 - Number of jobs created
 - Number of local patents and trademarks registered
 - Contribution towards tax revenue
 - Cost savings