

**INSTITUTIONAL PRACTICES IMPEDING
COMMERCIALISATION OF INNOVATIVE TECHNOLOGY
SOLUTIONS: A CASE OF SELECTED TVET INSTITUTIONS
IN KENYA**

BY

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DECLARATION**Declaration by the candidate**


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DEDICATION

To my lovely mother Evaline Kiberenge

ABSTRACT

For over a decade, the Technical and Vocational Education and Training (TVET) system in Kenya has witnessed increasing demands to undertake technology innovations with commercial intent. Although this goal is not to be achieved at the expense of skills training, the drive has attracted funds and grants purposed to stimulate catalytic activities in innovations. In response, TVET institutions have endeavoured to develop programmes geared to promoting technology innovations. This study was envisaged from observations that although there existed innovative products, there commercialisation rate remains insignificant. A challenge exists in converting innovations to commercial products. This study assessed the institutional practices of selected innovative TVET institutions that impede commercialisation of their innovative technology solutions. A conceptual framework of open innovation model was used. The study assessed the use of external technology, value creation and collaboration in promoting commercialisation of innovative technology solutions. A descriptive survey research design was used. TVET institutions in Kenya, which were actively involved in technology innovations and whose innovations were ranked highly were selected by a simple random method. Heads of these TVET institutions and Lead officers in government agencies concerned with innovation commercialisation were interviewed. TVET innovators responded to a questionnaire. Data collection employed interview schedule, questionnaire, document analysis and an observation guide. A pilot study was conducted to assess the validity and reliability of research instruments. Research data was analysed by descriptive, correlation and exploratory factor analyses. The study revealed that innovators and TVET institutions were inadequately equipped to undertake competitive commercial innovations. Most innovators had little or no training related to innovation commercialisation. More so, technology innovations were not treated with the seriousness deserved to commercialise them. It emerged that TVET institutions were under-utilising their internal infrastructure, external partnership, human resource and thus hampering their efforts to commercialise. A model of commercialisation of innovative technology solutions was developed. It emphasised on a strong interlinkage in development of audacious internal policies and processes that spark innovations with commercial intent, utilisation of collaborations and institution's resources for production of market competitive products. The study recommended formulation of enabling policies, training of innovators in innovation commercialisation skills, promoting collaborative practices, adaption of robust market strategies among others. This study will be significant to government agencies, TVET Authority, TVET institutions, industry players and other stakeholders who are involved in funding innovations and developing policies aimed at promoting innovation commercialisation.

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ABBREVIATIONS, ACRONYMS AND SYMBOLS

APEC – Asia-Pacific Economic Cooperation

CEO – Chief Executive Officer

EFA – Exploratory Factor Analysis

IMechE - Institution of Mechanical Engineers based in United Kingdom

ICM - Integrated Commercialisation Model

IPR - Intellectual Property Rights

GII – Global Innovation Index

KATTI – Kenya Association of Technical Training Institutions

KENIA – Kenya National Innovation Agency

KIPI – Kenya Industrial Property Institute

KIRDI – Kenya Industrial Research and Development Institute

KMO MSA - Kaiser-Meyer-Olkin Measure of Sampling Adequacy

MoE – Ministry of Education

MoEST – Ministry of Education Science and Technology

MoLSP - Ministry of Labour and Social Protection

MoU – Memorandum of Understanding

NACOSTI – National Commission for Science, Technology and Innovation

NIST – National Institute of Standards and Technology (USA)

RMUOHP – Rocky Mountain University of Health Profession

RVTTI – Rift Valley Technical Training Institute

SDGs - Sustainable Development Goals

ST&I - Science, Technology and Innovation

TISCs - Technology and Innovation Support Centres

TTI – Technical Training Institute

TVET - Technical and Vocational Education and Training

UN - United Nations

UNESCO – United Nations Educational, Scientific and Cultural Organization

UNEVOC – International Centre for Technical and Vocational Education and Training

U.S. SBA – United States Small Business Administration

UNDP – United Nations Development Programme

WIPO - World Intellectual Property Organisation

WPI – Worcester Polytechnic Institute

OPERATIONAL DEFINITION OF TERMS

Commercialisation:	The deliberate process of bringing a new or improved product or service of technological nature to the market.
External technology:	Knowledge and/or technology that originates from outside the organisation or institution of learning.
Innovation:	The process of developing a new or improved technology based product, physical gadget, a service or an equipment. It also refers to the item itself.
Innovative Technology:	A product or process that has been developed using a technological approach and in itself operates in a way or ways that, until its inception, have not been conceived or implemented before.
Innovator:	A trainer in a TVET institution involved in innovation of technology solution.
Innovators:	TVET trainers who consistently and actively participate in innovative technology activities in their institutions.
Technology solution:	A product or service that apply scientific and technology knowledge, principles and applications to solution day to day problem in the community or wider society in the locality of a TVET institution.
Technosphere:	The realms of applied technology that are influenced and shaped by trends, innovation, applied research and commercialised innovations.

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CHAPTER ONE

INTRODUCTION

1.1 Chapter overview

This chapter discusses the much emphasised need to innovate and the lesser stressed need to commercialise innovations which Technical and Vocation Education and Training (TVET) institutions continue to realise. It covers the problem that exists and identifies a knowledge gap for TVET players. The chapter includes the purpose of the study, objectives, research hypotheses, justification, significance, assumptions, scope, limitations and theoretical framework of this study.

1.2 Background of the study

In many parts of world, TVET systems are undergoing reforms and reorganisation (de Otero, 2019). These changes are not just aimed to improve education and training but also to respond to the ever increasing demand on TVET institutions to solving many socio-economic needs in their ecosystem. This has given rise to innovations in provision of relevant skills, applied science, involvement in entrepreneurship, incubation of new technology firms, consultancy activities and diffusion of technology for Small and Medium Enterprise (SME).

The core mandate of the TVET sub-sector in any country is to provide skilled training for competitive employable human resource that is needed for its country and locale (Ministry of Education, 2016). Alongside providing the much needed training, TVET providers are also expected to undertake other roles such as research, innovation and operating innovative units which are in-line with their training. These latter roles are emphasised in a recent report by the Ministry of Labour and Social Protection (MoLSP) which calls upon Education and Training institutions as sources of innovation and

technological advances to link with the industry with an aim of promoting technology transfer as well as knowledge based and innovation – driven economy (MoLSP, 2023). In that regard, TVET institutions are acknowledged and listed as one of the producers of innovations for a knowledge-based economy (UNDP, 2022). However, in their pursuit of these other roles and activities, it is expected that training for skills development at TVET training institution should not be compromised.

TVET institutions across the world are now adopting a systematic approach to innovation which combines innovation and skills for employability at institutional level (de Otero, 2019). This is out of the realisation that a TVET system should also contribute to social and economic challenges faced by the community and society in which it is established.

TVET has been used by several developing countries as an instrument of sustainable development though its significance has not really been embraced (Wahba, 2016). Different systems and mechanisms in an effort to breed entrepreneurial culture have been set up at both national and institutional levels. In a worldwide study de Otero (2019) advocates that TVET institutions should engage in income-generating activities directly drawn from innovations.

These institutions need to restructure their internal operations so as to accommodate officers who will be in-charge of commercialisation of innovative technology. Currently, most TVET institutions in Kenya have research departments and Intellectual Property Rights (IPR) officers but lack officers in-charge of technology innovation and its commercialisation. In addition, to succeed in innovative technology commercialisation some drastic measures such as changing the governing laws of TVET institutions may be required in order to make it possible (de Otero, 2019).

Durango (2002) observed that many countries in sub-Saharan Africa have at some stage embarked on the policy that advocates for the commercialisation of training institutions and the creation of a competitive training market. One of the major tenets of this policy is the encouragement of income generation by training institutions through training with production. This is an important aspect for TVET institutions as it plays a direct role in economic development of a country and can be significant in laying a strong foundation in achieving sustainability in development.

However, there seems to exist a challenge in achieving profitability from the innovations realized. As simple as it may sound, commercialising technology oriented innovations is not a simple task. It has to be noted that innovative technology solutions are not just time intensive but also consume lots of resources in the process of their invention and development yet beyond this phase very little comes out in terms of commercialising the innovations. At the University of Auckland, it is generally observed that an institute needs a strong process behind great research in order to harness the commercial opportunities that arise from innovations (Symons, Doone, & Nygren, 2017). To this extent, University of Auckland has an organisation tasked with the mandate to partner with businesses and assist its researchers to commercial research ideas.

The approach has seen the development of companies like PowerbyProxi, Stretchsense, Objective Acuity and SapVax in the field that ranges from power electronics to medical devices. This partnership also involves identifying strategic partners in the industry. These partners precisely enunciate their desires in product performance, then the university through its expertise, decides whether the university can pursue and innovate to satisfy the companies' specific requirements.

In most developing countries, TVET systems are expected to play two crucial roles in the national sustainable development (social, economic and environmental

development). The first role is to provide training opportunities and career advancement avenues for the increased school leavers. The second role is to provide skilled manpower that is needed at all levels of the economy. The skills so developed are expected to make a TVET graduate a self-reliant person in the absence of salaried employment and enhance the industrialization process (Wahba, 2016).

In Kenya, the Ministry of Education has for a long time challenged TVET institutions to undertake research activities that may lead to development of bright ideas and innovative technology. The ministry hopes that such developments can lead to innovative products and services which would contribute to economic success of the country as well as provide new job opportunities. It further advocates that innovations increase the capacity to solve societal problems (RVTTI, 2020).

According to the World Intellectual Property Organisation (WIPO), Kenya was ranked 88th out of 132 economies in the Global Innovation Index (GII) in 2022 (WIPO, 2023). This index ranks world economies based on their innovation capabilities using about 80 indicators for innovation inputs and outputs. This shows that Kenya is sliding down the rank having been ranked 86th and 85th in 2020 and 2021 respectively. However, the same indicator shows that Kenya has a potential to better grow its economy if it improves its innovation commercialisation processes as this would translate into economic development.

Therefore, it is of great interest to this study, that even government agencies in Kenya have noted with concern that Science, Technology and Innovations (ST&I) players need to dialogue in order to address the various issues limiting the commercialisation of their products and services (NACOSTI, 2019). The Kenyan Parliament in 2022 passed an Act of law to redefine the mandate of Kenya Industrial Research Development Institute (KIRDI). The KIRDI Act of 2022 promotes collaboration between the institute and

training institutions (Republic of Kenya, 2023). The TVET Act (2013) on its part, promotes collaboration of TVET institutions and industry. These pieces of legislations serve to reinforce the desire of the Kenyan government to have TVET and other training institutions contribute to economic development of the country. This desire is clearly stated as the second specific objective of TVET (Ministry of Education, 2016) which requires transfer of technology be continuously through collaborative approach between TVET institutions and relevant industries. TVET institutions, through their trainers and learners, have set up multiple programmes to encourage technology innovativeness. The desires of concerned government agencies are that these undertakings in innovations have to culminate to tangible returns.

In Kenya, many TVET institutions have tried to embrace this call by the Ministry of Education (MoE) to innovate. However, just a handful of the institutions have demonstrated the willingness, skilfulness and determination to support their localities in their efforts to innovate, despite facing challenges in developing their technology solutions into business ventures. The bottlenecks constraining these handful of institutions have left them in a precarious state in which they have to grapple with underfunding in research and innovation activities since most of them simply depend on government funding. This high dependence syndrome could be eased if technical institutions would see their novel innovations commercialised.

1.3 Statement of the problem

The Government of Kenya and many other agencies have encouraged technology innovations in TVET sector through policy formulation, provision of innovation funds and incubation support to most institutions including those in TVET. In turn, TVET institutions have developed and embraced initiatives aimed towards promoting innovative technology solutions at institutional level.

Despite these efforts, challenges still exist in advancing innovative technology to the next level which is technology commercialisation. Like in most parts of the world, the innovations seem to die at the exhibition and showcasing stage of the process.

As noted in APEC (2018), an inherent challenge in commercialization of public and academic research processes is bridging of the gap between basic research and commercialization. The implication is that on one side there exists innovations and on the other side there is fund to commercial but in between there is a missing link. This has led to a lower commercialisation rate of innovative technology solutions.

The missing link concerns has been raised by both National Commission for Science, Technology and Innovation (NACOSTI) and the then Ministry of Education, Science and Technology (MoEST) as they clearly state that the ultimate goal of funding research and innovations is to see them turned into commercial projects that would create employment opportunities, boost the country's economy and reward innovative institutions with a source of revenue (NACOSTI, 2019). NACOSTI further points out that most parties involved in technology innovation are not aware of how to commercialise their products and services.

This lack of awareness render expectations to commercialise innovative technology a far dream. As a result, technology innovations continue to die as they are unable to cross the interface to commercialisation. It is also unfortunate that while this continue to happen, the funds for supporting innovation and commercialization continue to be scarce. The little available funds could be utilised to create more funds in form of revenue resulting from commercialised technology innovations. This is important if the whole the process is to be self-sustaining. This study therefore investigated the practices pursued by TVET institutions as they innovate technology solutions for commercialisation. The initiated processes that form their strategies have borne different

degree of success and failure alike in the commercialisation phase for their innovative technology products and services. These practices seem to be hampering the effort to commercialise their innovations. Therefore, the study sought to establish the missing link between technology innovations and commercialisation of these innovations. By establishing the bridge to commercialisation, TVET institutions will be able to increase their rate of innovations commercialisation and thereby reap more benefits from their efforts.

1.4 Purpose of the study

This study examined institutional practices which impede efforts by TVET institutions to commercialise their innovative technology solutions. Through interrogation of these practices, the study established the upside and downside of TVET institutional practices as they strive to advance their innovative technology solutions to the commercial stage. The study also modelled practices for successful commercialisation of innovations in TVET institutions in Kenya. The study made recommendations, which were based on the findings on how TVET institutions can effectively commercialise their innovations.

1.5 Objectives of the study

This study focused on the objectives indicated below.

1.5.1 Main objective of the study

The main objective of this study was to examine practices which hamper TVET institutions from effectively commercialising their innovative technology solutions.

1.5.2 Specific objectives of the study

The specific objectives of this study were to:

- i) Assess the use of external technology in promoting commercialisation of innovative technology in TVET institutions.
- ii) Examine the extent of value creation in promoting commercialisation of internally developed innovative technology solutions in TVET institutions.
- iii) Determine the influence of collaboration in enhancing commercialisation of innovative technology in TVET institutions.
- iv) Develop a model for effective commercialisation of innovative solutions in TVET institutions.

1.6 Research Questions

This study was guided by the following questions:

- i. In what ways is external technology used in promoting commercialisation of innovative technology in TVET institutions?
- ii. To what extent is value creation promoting commercialisation of internally developed innovative technology solutions in TVET institutions?
- iii. What influence does collaboration have in enhancing commercialisation of innovative technology in TVET institutions?
- iv. Which model is effective for commercialisation of innovative solutions in TVET institutions?

1.7 Justification

Through technological advances, new jobs and industries are created. These avenues provide job employment opportunities for the technologically educated and skilled youth. Moreover, for attainment of economic growth commercialisation models specific to technology innovations need to be development especially for developing economies (APEC, 2018). In Kenya, there are very few manufacturing industries that specialise in

production of Kenyan innovated products despite the encouraging innovations that have been witnessed in different technological fields and in institutions (Newman, et al., 2016).

By establishing the existing dis-connect between innovations and their conversion into commercial ventures, this study could open avenues for bridging that link. With the link bridged, Kenya and its TVET institutions could begin to reap benefits from their innovations. Furthermore, it could lead to emergence of new industries that would provide the much needed jobs and boost the overall economy of the nation.

In addition, little research had been conducted in this area of commercialisation of innovative technology products that were developed by TVET institutions. There was need to carry out such a study which intended to fill the knowledge gap in this area and to assist TVET institutions attain one of their goals in innovations.

1.8 Significance of the study

This study was important in assisting TVET institutions to discover their strengths, weaknesses, experience, abilities and knowhow with regards to converting their innovations into market products. When armed with the knowledge on commercialisation of technology innovation, TVET institutions stand a chance to spur the Kenyan economy into an innovation driven economy.

This study aimed to generate knowledge within these precincts. It was apparent that lots of funds were spent in innovative technology and therefore prudent that such funds should be recuperated in form of resulting revenue. This revenue could then be plunged back into creating more innovations and hence create a sustainable cycle of funding innovation and commercialisation. According to NACOSTI (2018), the funding for innovation is still insufficient and it hopes that more other sources of funds will emerge.

Major beneficiaries of this study will be TVET institutions, the National Research Fund (NRF) and the Kenya National Innovation Agency (KENIA). Similarly, heads of TVET institution, staff, innovators, technology entrepreneurs, business representatives, innovators, students and other stakeholders in TVET will understand the processes and the basics of successful commercialisation practices in TVET institutions.

Government agencies on their part, will be able to evaluate the likelihood of their innovative funds to bear innovations that are likely to be turned into commercial projects. NRF for instance, will find it necessary to fund TVET institutions that have such structures and characteristics that support a higher potential to commercialise innovations. It was envisaged that the study will uncover the missing link between innovative technology solutions and market commercialisation of such innovations.

1.9 Assumptions of the study

A number of assumptions formed the basis of this study. One such assumption was that TVET institutions practice innovations in technology with the ultimate intention to commercialise the resulting products, which may include goods and services. It was also assumed that the innovators in these institutions strive to possess the relevant skills, attitudes and knowledge that would enable them commercialise their innovations.

In addition, the study assumed that the innovators and relevant authorities deliberately and proactively pursue means to ensure that innovative technology solutions were commercialised in TVET institutions. Another assumption relied upon in this study was that the information provided by the respondents and other research instruments was a true reflection of the state of affairs at the time the study was conducted.

1.10 Scope of the study

This study was expected to be conducted within two years. Its scale was restricted to innovative technology by TVET institutions in Kenya. These included innovations which emanated from these institutions or which the institutions got to participate in their development with its innovation partners. The study focused on the undertakings of these institutions in propelling such innovations to the stage of commercialisation.

The study confined itself to technology innovations which dated between the years 2012 and 2019. It was further limited to bridging the gap between innovations and market the innovations.

1.11 Limitations of the study

The study was limited to commercialisation of innovative technology by TVET institutions. It relied upon information provided by respondents and available documentation. The respondents' knowledge, enthusiasm and experience in processes of commercialising innovative technology was expected to have some influence in the findings of this study.

1.12 Theoretical framework of the study

The theoretical framework underpinning this study was a proposed concept of “open innovation” by Chesbrough (2003a). Prior to the open innovation model organisations exercised strict control over their innovations. Enterprises would develop own ideas and proceed to manufacture the products on their own. They would then market, distribute and service their innovations all by themselves (Chesbrough, 2003b). One drawback with such an approach was that organisations did not possess financial and intellectual muscles and therefore, could not successfully innovate in technology.

In the open innovation model, shown in figure 1.1, organisations can commercialise technology both externally and internally. The figure shows the firm's boundary (indicated by dashed lines) between an organisation and its ecosystem is porous and thus enables innovations (indicated by small circles) to flow freely in and out of the organisation (Chesbrough, 2003b). The significance is that small organisations such as TVET institutions could find alternative avenues to develop, improve, manufacture and market their in-house ideas and innovations. This can be achieved through collaboration with external firms. Hence with such model, TVET institutions have an opportunity to commercialize their ideas as well as innovations from other firms.

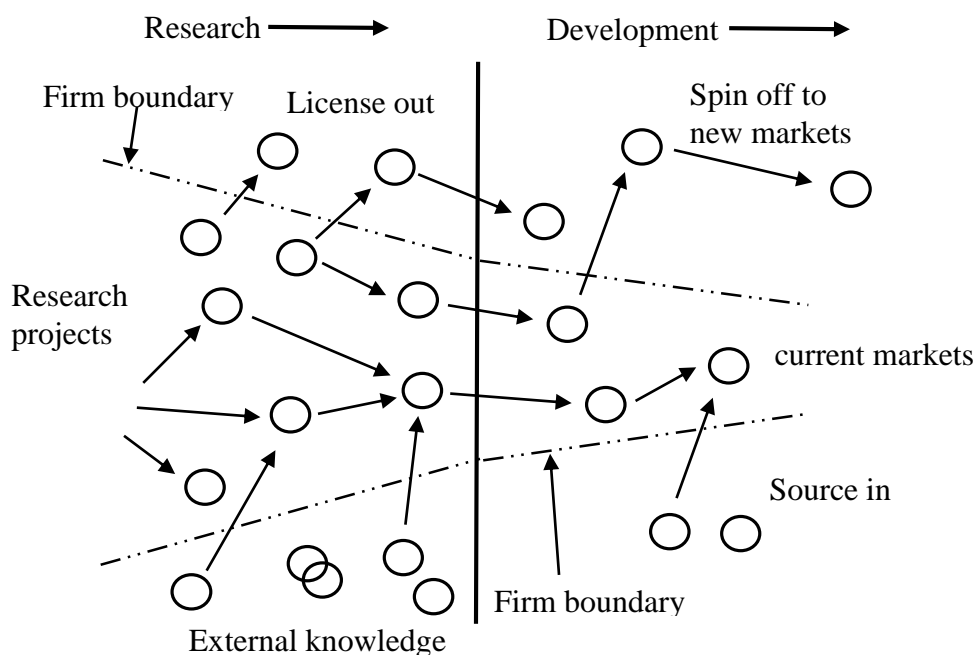


Figure 1.1: The open innovation model

Source: Chesbrough (2003a)

Two core philosophies are advocated by the open innovation model. The first philosophy encourages organisations to use external knowledge and technology to strengthen their own innovations. The second philosophy promotes the concept that

organisations should strive to create value from internally developed innovations that are not immediately applicable in their own business.

This paradigm underscores the need for both internal and external collaborations. It further urges that organisations should strive for joint strategies in innovation and subsequent commercialisation. For TVET institutions, this is important as joint strategies would harness industrial minds in terms of production design, marketing, distribution and market assessment.

The model further advocates for two approaches, which are inward open innovation and outward open innovation. Inward open innovation has to do with externalising and diversifying sources of innovation beyond the organisation's departments. Forming collaborations and partnerships expand sources of innovations thereby increasing the chances of innovating commercially viable products and services. The arrows indicate the direction of flow of innovative ideas and projects. Some innovative ideas and projects inform other innovations within the organisation, such as TVET institutions, but can also cross the porous boundary to be used by external players.

On the other hand, it suggests that innovations that do not have a direct usage in the company should be taken out through licencing, joint ventures or spin-off. This is referred to as outward innovations. This approach acknowledges the fact that the dramatic rise in mobility and knowledge of human resource poses a difficult challenge in confining organisation's ideas and innovations to its own boundaries. It points out that the growing availability of private venture resources which has given rise to emergence of new firms and efforts to commercial ideas that are now availability outside their own incubation firms.

This framework acknowledges that very few single entity or organisation can conduct research innovations then proceed to develop products and commercialise them by itself. Most lacked resources to generate, develop and commercialise their own ideas.

This view resonates well with the Kenyan situation, making this framework particularly suitable for TVET institutions in the country. In Kenya, most TVET institutions are endowed with brains capable of carrying out innovative research. However, many institutions have less capacity in terms of industrial production capability.

Moreover, institutions either set aside or receive funds for innovation and may not necessary receive extra funds to market their innovative products and services. In such scenario, it would be prudent for TVET institutions to explore other viable alternatives for their innovations to reach out to the market. Such options would be to form partnership with other like-minded organisation and business ventures. On the other hand, most industries have limited resources to carry out research activities but have facilities that can be used for production of commercial technology innovative products.

1.13 Conceptual framework

A conceptual framework that encompasses the key components that the research investigated is shown in figure 1.2. This framework is organised in such a way as to distinguish constructs that were of interest to this study (Shields & Tajalia, 2006). Three kinds of institutional practices that enhanced the likelihood of commercialisation of innovations in TVET institutions are shown. They included the use of external technology, creating value from internal development and lastly partnership and source-in of ideas, products and services. The fourth component, model of commercialisation, is a resultant of an evaluation of the three practices.

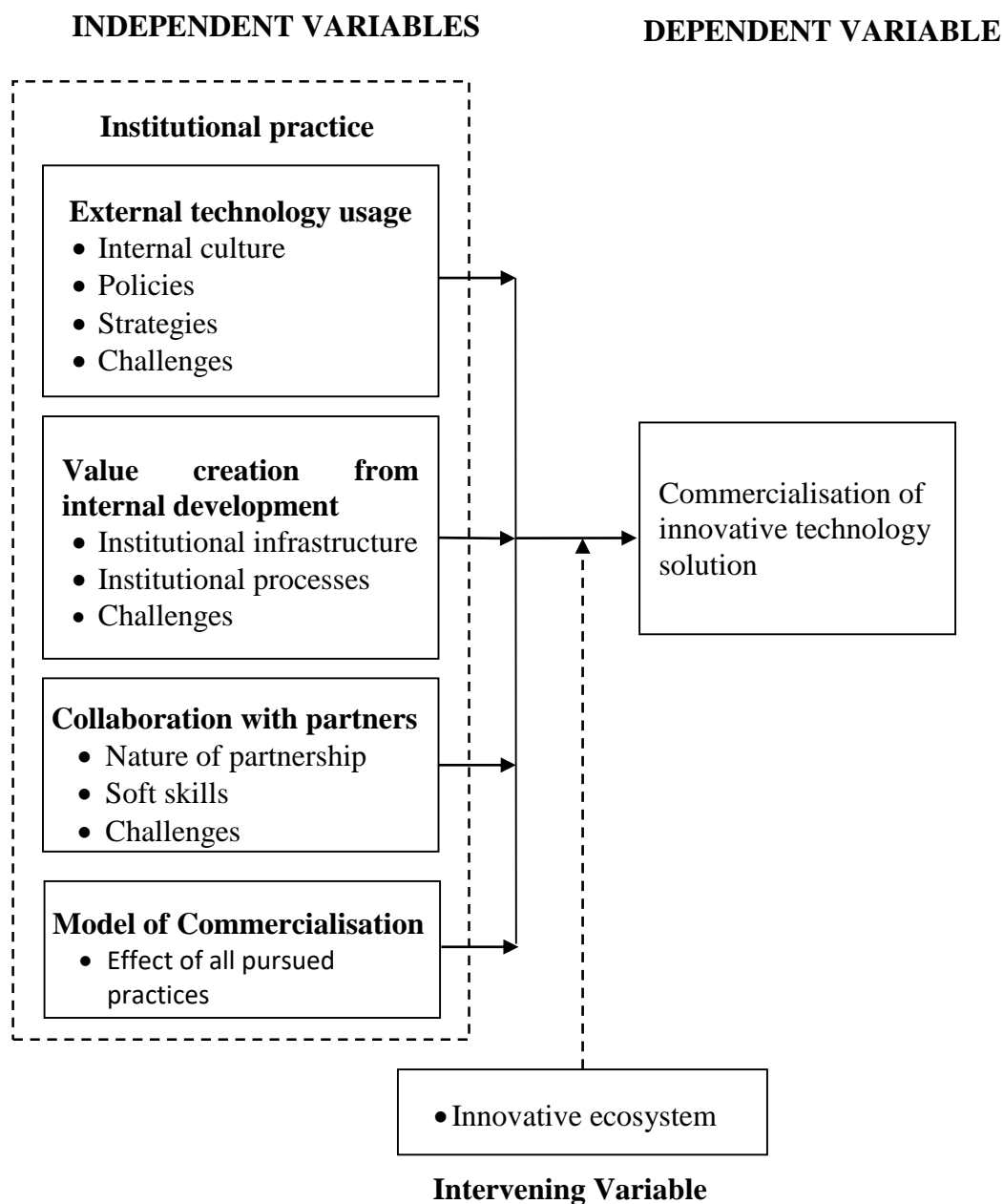


Figure 1.2: Conceptual framework for the study

(Source: Author, 2021)

On the other hand, no matter how hard TVET institutions innovate, the innovative ecosystem in the country plays a significant role in either supporting or hampering the overall ability of the national systems to commercialise whatever products and services they got. This ecosystem can neither be determined nor controlled by the TVET institutions. It is an environment that has been shaped over many years by government

policies, national infrastructure, national resources, industry investments, market demands and much more. The study investigated the extent to which TVET institutions engaged in such practices as to cause success or hindrance in their bid to commercialise their innovative technology solutions.

1.14 Chapter summary

The drive for TVET innovations does not start and end at display of innovative solutions. The benefits of such innovations are meant to be realised in the ultimate commercialisation stage where they benefit the community and nation at large. This realisation has been a great challenge to TVET institutions. This study highlighted practices that seemed to achieve this goal and hopes to be beneficial to TVET players whose concern is in innovative works. The study used an open-innovation concept to pursue its objectives.

CHAPTER TWO

LITERATURE REVIEW

2.1 Chapter overview

In this chapter, the theoretical basis of commercialisation of innovative technology solutions has been discussed. This includes review of existing literature on commercialising innovative technology solutions by the industry and tertiary training institutions. It also reviews a number of commercialisation models that have been developed in different fields. The chapter then brings out the knowledge gaps that the research pursued to address.

2.2 The concept of commercialisation of innovative technology

Any original concept can be considered to be an innovation. This may be either a new or improved device, product, material, business model, process or service. The true test of whether an innovation can become a business success is when: a new device, product or service becomes accepted by the market, a new business model or process improvement delivers cost savings, efficiency gains or productivity improvement that translates into a competitive advantage (Queensland Government, 2020).

For commercialising innovation, there is need for existence of an innovation ecosystem that models an economic approach. This ecosystem's serves to converge and relate various players who in the long run support the development of technology, innovation and its marketability (Symons, Doone, & Nygren, 2017). As a result, the ecosystem sees the merging of material resources, human capital, researchers, innovators in learning institution, state organs, funding agencies and industrial experts, which serves as a catalyst to realising the dream to commercialise innovations.

Generally, it has been noted that very few innovations end up in the market, leave alone making money for their creators. That means that many innovative technology solutions do not get the opportunity to reach the society and solve societal problems. According to Jackson (2010), many potential innovations fail to cross the gap from inventions to business due to lack of resources. These resources that were lacking were identified to be funds and human capital, with lack of funding being a critical one.

The challenge of commercialising scientific research is faced by even research institutions. In Poland for instance, it was pointed out by Malec, Stanczak and Ricketts (2020) that there was need for Polish research institutes to embrace technology transfer and commercialisation of scientific innovative solutions. They noted that the challenge that is faced by research institutes in regard to commercialising their outputs has not been analysed. The authors further noted that prospects of commercialising research output in Poland has been given much focus in the academia and entrepreneurs' sectors thus leaving behind research institutes. A similar case could be advanced for TVET institutions in Kenya in that many Universities have been conscious of commercialisation prospects have institutionalised scientific research for business gains while many TVET institutions are still grappling with internal structures and strategies that are needed to support commercialisation prospects for their technology innovation solutions.

In Africa, some governments have realised the importance of commercialising innovations and are actively taking direct initiatives to bridging the gap. Like many other developing nations including those in Africa, building a knowledge economy still poses a great challenge (Piotrowski, 2015). However, there are initial successes in Africa to harness the commercial benefit that comes from its research and innovations.

Knowledge economy could be realised if Africa overcomes poor connectivity and lack of trust amongst the innovators.

In Nigeria for instance, the Nigerian Communication Commission holds competitions for technology innovations on a regular basis. In these competitions, the commission awards three most promising commercially viable innovations. This undertaking reveals that the Nigerian government understands the need to commercialise innovations and the problem of inadequacy of funds that innovators face which hinders their ability to take their innovations to the next level.

In Kenya, the agency in-charge of innovation, KENIA has been spearheading efforts to have them commercialised. The agency, however notes that there is still low support from investors to commercial innovations (Otieno, 2021). Similarly, lack of funds to support commercialisation of technology solution for TVET institutions continue to be a big setback (RVTTI, 2020). Although innovations have been encouraged in most TVET institutions in the country, the institutions have failed short at embracing their commercialisation with the same eagerness. They seem just to reward innovations with some awards and tokens.

From studies conducted, TVET institutions among others have set up enticing awards to create an encouraging and enabling environment for innovations to thrive (RVTTI, 2020). This is a positive indicator that shows TVET institutions are putting value to innovations. On the other hand, such initiatives only serve to attract more innovations and more proposals for innovations. Unfortunately, the thriving for more innovations does not necessarily translate to their commercialisation. Deliberate sensitisation, mobilisation, upskilling, trainings and investments are need to drive the commercial phase of innovation. The TVET institutions have to understand and embrace the process

to creating commercially viable innovations for any positive achievements to be realised.

A totally new approach is to be adopted to realise the business perspective of innovations. TVET institutions have to proactively follow a scheme that provides deliberate strategic actions that are intended to attract entrepreneurial partners, knowledge experts, start-up companies, product consumers and much more in order to commercialise their innovations.

2.3 The concept of institutional practices and commercialisation of technology innovative solutions

Various factors come into play to influence the intensity of commercialisation of innovations. Human resource development and communications within the organisation are just some of the crucial areas that must be considered and improved to have successful business oriented innovations. Commercialising innovation culture is important to every organisation if it has to stay relevant and challenge the status quo (Symons, Doone, & Nygren, 2017).

It was noted by Schaufeld (2015) that there exist abundance of projects and ideas which require organisations to rethink better strategies of converting them into commercial opportunity. Some nations like the United States of America have even formed a national committee to inform, advise and recommend to players in the innovation ecosystems on entrepreneurial matters regarding invention and innovations (U.S. SBA, 2022).

In a study by Malec et al. (2020) on commercialisation of scientific research results and development projects, it was pointed out that there exist problems in the field of engineering when innovative solutions have to be transformed to have a business character. It then developed a model referred to as an Integrated Commercialisation Model (ICM).

The foregoing argument applies to TVET institutions since institutional practice has been identified as one of the four dimensions that need addressing in a TVET institution. This is so especially whenever describing an aspect of developing and implementing an innovations (de Otero, 2019). This dimension concerns itself with planning, finance, human resource management, administrative structure, and internal monitoring and communication. The other three dimensions are ecosystem, teaching and learning processes and lastly, products and services.

The capacity to conceive, nurture and incubate innovations is highly dependent on the institution's practices. These practices encourage innovation and business development of the resulting products and services. However, a number of institutions seem not to have realised the importance of a strong institution practice in development and enhancement of business oriented innovations. A few though are becoming cognisant of this weakness on their part and are undertaking bold initiatives to overcome this challenge.

As noted by de Otero (2019), TVET organisations tend to focus on products or services, processes and external relations when pursuing innovation activities with less attention on innovation in organisational practices. IMechE (2020) observed that it is not just enough to have a customer-centric approach, rather an organisation needs a strong framework and a dedicated team that can spot opportunities and drive her innovation process towards marketing their products.

One approach that has been used by other entities is to actively get involved in promoting and incentivizing innovative thinking and directly fund the same so that the products can be commercialised (RVTTI, 2020). Despite the efforts, having the right institutional practices continues to be a challenge for most TVET institutions in Kenya.

It is not clear whether many TVET institutions wish to achieve the goal of commercialising their innovations as most continue to be confined and terminate at the innovative stage with little or no successful progression to the next phase. This brings forth the notion of whether TVET institutions are innovating just for the sake of it. Symons, Doone, & Nygren (2017) raised some questions that guide an organisation on whether it is raising innovation for commercial purpose or just innovating for the sake of it. The questions are as follows:

- i) Who owns the innovation process in your organisation?
- ii) Is there focus purely internal or are they also identifying external partnership opportunities?
- iii) Who do the innovators report to? The Chief Executive Officer (CEO) or another executive?
- iv) How is your organisation identifying and generating new ideas to explore? Is this process technology-led or focused on customer problems?
- v) Does your company culture support or stifle innovative ideas?
- vi) At what stage are you involving customers in the innovation process?
- vii) How advanced is your exploration of the innovative technologies?
- viii) Are you focused on more mature technologies, or are you also exploring those that are still emerging?
- ix) What is the innovation process you are using to turn ideas into viable products?

Upon answering these questions then another important question to ask is, “what exactly should the institutions do to have their innovations fit for market production?”

2.4 Use of external technology to enhance commercialisation of innovations

Organisations are encouraged to use external technology to strengthen their own innovation and thereby placing them in a good position to be commercialised. For

institutions to innovate for commercial gains, they need to possess an internal culture that supports innovation. Such a culture would advocate for an open innovation model.

The institution should be open to the fact that there exists an abundance of knowledge which can be shared in order to provide value benefits to organisations that care to seek it. This could be demonstrated through incorporating aspects that are external to the institution and infusing them to the innovative processes. Some ways of doing this involve inviting experts for technical guidance, acquiring special equipment or technology, seeking market information and partnering with manufacturers.

In the same spirit, the organisation should be willing to share its own knowledge with intention to benefit external users. As noted by Carroll, (2014), an organization should not restrict the knowledge that it uncovers in its research to its internal market pathways, nor should those internal pathways necessarily be constrained to bringing only the company's internal knowledge to market.

In the University of Auckland's commercialising innovation framework includes step three which is to take a customer-centric, outside-in approach to innovation (Symons, Doone, & Nygren, 2017). The customers' problem has to be clearly understood and a technology innovative solution be tailored to suit that need. This approach relies in ability to explore the niche market and the many merits that come with such exploration (Farhana & Swietlicki, 2020).

Another approach which organisation use to incorporate external input into their innovative products is by setting up of innovation Committees. De la Pena- Anguiano et al. (2022) pointed out that innovation committees play a significant role in managing the innovation process including securing the intellectual property right for the product.

By doing so, the committee raises the probability that the product line will survive the process towards commercialisation. It also cuts down on the overhead costs of running the whole process since it develops sound mechanisms of process management including liaising with the market to obtain market information, competitor awareness and keep a database of products both within and externally.

TVET innovative technology solutions have to meet the criteria to be commercially feasible. This criterion among other requirements include satisfying the customers' need. It is only after the customer's need has been satisfied that innovated product stand a better chance to be accepted at the market.

An institutional practice that supports talent and innovations plays an important role in harnessing and fostering talents that will eventually lead to innovations and commercialising of such innovations. When this particular culture lacks then potential innovators experience a barrier and difficulties in corporation within themselves and with other external actors (Symons, Doone, & Nygren, 2017).

A study on innovation in TVET found that TVET institutions have a weakness in forging and promoting technology diffusion as compared to other higher learning institutions and research centres. This was blamed on the over tendency of TVET institutions to focus more on providing solutions in skills development rather than pursuing both (de Otero, 2019). If TVET institutions give both approaches equal preferences, then TVET institutions would not only achieve their mandate of producing skilled labour but also realise the benefits of commercial innovations.

A case of open model innovation versus closed innovation model can be cited of two companies, Lucent and Cisco, all in the same industry and competing for the same market segment. Lucent pursued the closed innovation model while Cisco pursued the open innovation model. Lucent mobilised its resources and invested lots of resources in

researching of new materials, components and systems that would lead to the state of art products (Chesbrough, 2003b). On the other hand, Cisco with an open innovation model sought its required technology from outside the organisation. It partnered with research organisations and invested in carefully selected start-ups and thereby avoiding conduct research of its own.

2.5 Value creation from internal development

For commercialising innovation, there is need to try and create value from internally developed innovations that are not immediately applicable in the organisations' own business. What is done with viable innovations is a determinant step towards commercialisation. There is need for TVET institutions to chart new approaches in all frontiers pertaining their mandate. Such approach in TVET spheres has been emphasised in a UNESCO strategic plan for TVET that spans from the year 2022 to 2025. It underscores the need for reshaping of TVET education system to explore beyond its conventional or traditional undertakings (UNESCO, 2022).

The cost required to explore a business opportunity of an innovative technology solution may vary based on the nature and scale of the innovation. Depending on the type of innovation and the category, some innovations may consume a lot of money to develop a prototype, test it and run a market test. This exploration cost may hinder the business development process of an innovation.

One other factor is a strong innovative process. There exists a natural gap between innovation and commercialising innovations. Innovators may themselves possess great commercial creativity skills that can lead to products entering the market at a faster rate and with a higher market awareness. A study of TVET policy noted that it is important for trainers in TVET to be taught entrepreneurial skills which could be passed to trainees and become job creators (Olayo, 2022). But this can only be realised as a benefit of

having a strong innovation process. Apart from being able to more quickly identify and commercialise ideas within the organisation, having a strong process can mitigate a range of issues, such as funding restraints (Symons, Doone, & Nygren, 2017).

In a study to investigate the prevalence of innovative skill amongst TVET graduates businesses Kithae et. al (2014) observed that graduates face certain challenges which included lack of finances and technical support and thus hampering their success in businesses. In their recommendation they asked for more funds towards start-up businesses and provision of equipment and tools.

TVET institutions however, face constraints such as lack of time, resources and staff to promote a strong innovative practices (de Otero, 2019). This has a negative impact on adding value to already existing innovative technology solutions. In addition, the study concluded that an action plan in TVET institutions is necessary for purposes of laying down a clear, practical and concrete actions to drive innovation processes forward. The plan has to include institution's motives and objectives, team building processes, indicators of innovation, measures of innovation, employee recruitment and development standards based on innovation, incentives (such as promotion and career opportunities) and appraisal for employees.

To create value internal innovations, TVET institutions may need to have sound resources which include good infrastructure and human capital. Material resources such as funds, production facilities, material resources and the process equipment may serve to boost commercialization in the face of innovation. It is also important to incorporate internally available human capital which include trainers, trainees and even serving industrial experts in the institution.

2.6 Collaboration in commercialising innovations

Just like innovation, commercialising innovation needs a collaborative approach amongst TVET institutions, entrepreneurial industry, end-users and other interested and relevant stakeholders. As pointed out by de Otero (2019) in the study of UNESCO-UNEVOC trends mapping innovations in TVET, the ecosystem dimension is key to any successful TVET innovations. This dimension concerns how TVET institutions interact with other partners and players in their technical area and locality. It outlines that collaboration can be through advocacy and promotion of external monitoring, networking and engagement. Which also include involvement in internationalization activities. Factor merits may arise with collaboration, this include well-articulated pathways for innovative processes and forecasting of future pathways. Challenges and problem solving is improved since the collaborating parties bring forth ideas from different perspectives.

Identifying a suitable collaborator or partner is key to the process success. The partnership has to be a robust and productive (IMechE, 2020). Partnership is important in the sense that it allows the other party to bring on board their capability with their relationships and experience within the category which fast tracks the whole process of commercialising innovations (Symons, Doone, & Nygren, 2017).

Different external actors have different strengths which they can bring to the innovative process. Some have the muscle to fund the innovation which may speed the process of funding. Malec et al (2020) observed that the size of a business organisation influences its business model especially its guiding principles to technology innovative solutions. Some innovate on the basis of achieving a sustainable socio-economic environment while others for economic purposes. This means that for TVET institutions to have collaborative venture with such partners they have to be in-line with the partners'

general guiding principles. On the other hand, training centres need to be supported to identify and access alternate sources of financing to support innovative process (de Otero, 2019). The institutions therefore have an obligation to create and nurture commercialisation practices within their institutions.

Licensing out of projects, joint ventures and allowing for spin outs are some of the ways TVET institutions with less capacity to undertake business development of their innovative technology solutions can utilise to realise the commercial phase of their products. In addition, the institutions can collaborate with other willing organisations to transfer trainers to enterprises and production industries.

The benefits of collaboration amongst independent institutions or organisations are immense because each organisation brings in its strength in the area of corporation. Instance, in ICM model a partnership of three has been outlined that would enable innovative solutions to be commercialised in the area of production engineering. In this model, a research institute generates ideas and research results. Then equipment manufacturer produces the equipment. Finally, a mineral miner who is the end-user tests the equipment and give suggestions based on their assessment of the equipment's performance (Malec, Stanczak, & Ricketts, 2020). This process establishes an iterative collaboration at each stage. It can be noted that in such a model, the process improves the economic viability of research results. However, it is also noted that the end-user in this model has already been identified and actively participating in product innovation process. It is important to note that the model creators state that the model is not a simple recreation of reality but an outline of determinates that increase the likelihood of successful commercialisation of innovative solutions in technology.

Innovations can fail to be commercialised on the basis that they fail to be customer centred. For innovative technology to be successively in the market it needs to address

the problems faced by the targeted users. This calls for a different kind of collaboration with the customer or clients. This type of collaboration calls for an outside-in approach in which customers give their input and experience with the innovative technology as it undergoes its development. With the user constantly shaping the process of innovation with constant feedback, the innovative solution will accommodate features desired by the market-needs. Consequently, the end product of innovation will be positioned in an advantageous position to even compete with the latest innovations that could be entering the market.

In a study to assess the success of commercialisation when there is collaboration with customers, it was found that these innovations were twice as likely to expect growth rates of 15 per cent or more over a period of 5 years (IMechE, 2020). This is supported by bringing user-driven requirements in every stage of the development. Similarly, case studies by Malec, Stanczak and Ricketts (2020) found out that three out of six innovative projects that were designed for commercialisation succeeded. In these case studies, partnership with end-users was initiated right from the start of the projects. These findings imply that TVET institutions have to focus on a customer centric approach quite early in the innovation process and keep the end-users' assessment in their innovations. Commercially viable innovations take the approach of customer-first rather than technology-first. The product or the service need to solve a real life problem.

Most studies in collaboration focus on improving the skills training of students with the help of the industry partners. These studies have focused on the quality of education and training. Some of factors that have been investigated include the learning environment, learning facilities and the contents of the curriculum in TVET institutions (Ferej, Kitainge, & Ooko, 2012). These studies have urged the enhancement of linkages between TVET institutions and the industry. This kinds of collaborations need to be

taken a step further that may enable the industry as key partners in embracing TVET institutions' innovative solutions by giving them an economic angle and playing a key role in commercialisation these innovations.

2.7 Models of commercialising innovations

Several models exist for different research institutions that undertake technology innovations with an intend to commercialisation innovation. This is out of realisation that it is not easy for scientists and researchers to walk the path of commercialisation as they invent their products. As noted by the Director of National Institute of Standards and Technology (NIST) of the USA, “the path from knowledge creation to application is often described as a smooth, straight line – but in reality, it is a very rocky, convoluted path with many mismarked exits” (Jeffrey, 2016). Therefore, models attempt to customise the commercialisation process to the specific institution in an effort to maximise the chances of research outputs to reach the market. Such models are hereby discussed.

2.7.1 Commercialisation and patenting model for Universities

Universities are mandate to carry out research in their effort to further advancement in knowledge and technology. The output of this pursuit can be patented and commercialised. By doing so, there is knowledge transfer and revenue for the university. The economic sector benefits as well. Siringi (2022), conceptualised a commercialisation and patenting model for universities' research output. Figure 2.1 shows this model.

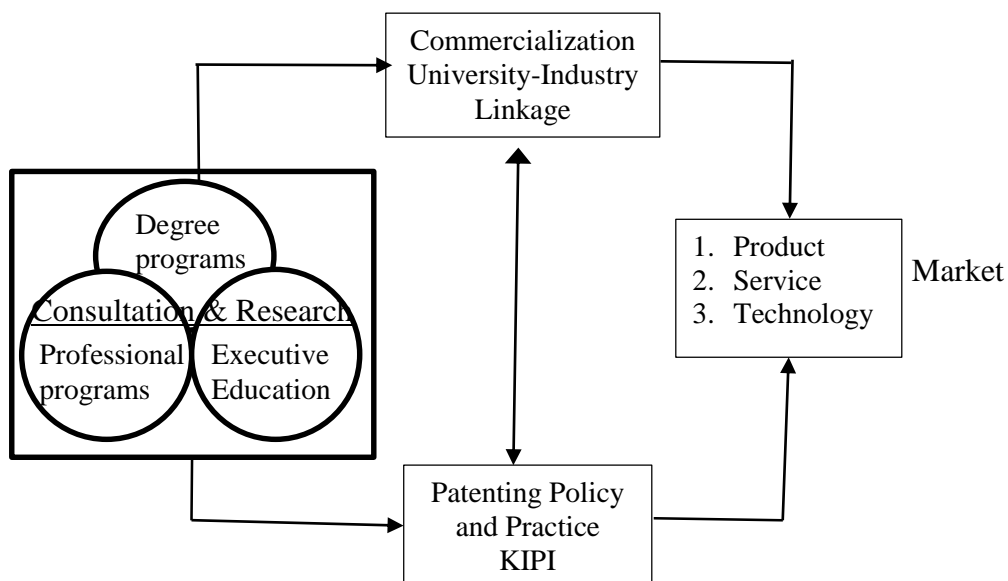


Figure 2. 1: Commercialisation and Patenting Model for Kenyan Universities

Source: Siringi (2022)

This model acknowledges the traditional role of the university as a learning institution that offers degree programs. In addition, the universities formulate new professional programs for professional training and executive education for executive training. Having acknowledged these roles, the model goes ahead to point out that the changes in contemporary society has increased the pressure for universities to play a significant role in creating a knowledge driven economy. It emphasises the need for universities to establish collaboration with industry in research. It observes that for universities to realise commercialisation of their research outcomes, they must take deliberate policy actions that link them to industry with an aim to invent, innovate, patent and commercialise.

2.7.2 The commercialisation model by Schaufeld

Schaufeld (2015) observed that there was an abundance of innovative projects and organisations that can provide economically viable technology products. Despite this positive potential, there were no indicators of proportionate economic growth.

Schaufeld noted that even with this abundance of innovative products it remains a complex task to convert them to commercially viable products. However, to achieve this feat, innovative ideas need a better approach, in form of a model, to be turned into entrepreneurial products (Schaufeld, 2015). Figure 2.2 depicts the Jerry Schaufeld's commercialisation model (WPI, 2017).

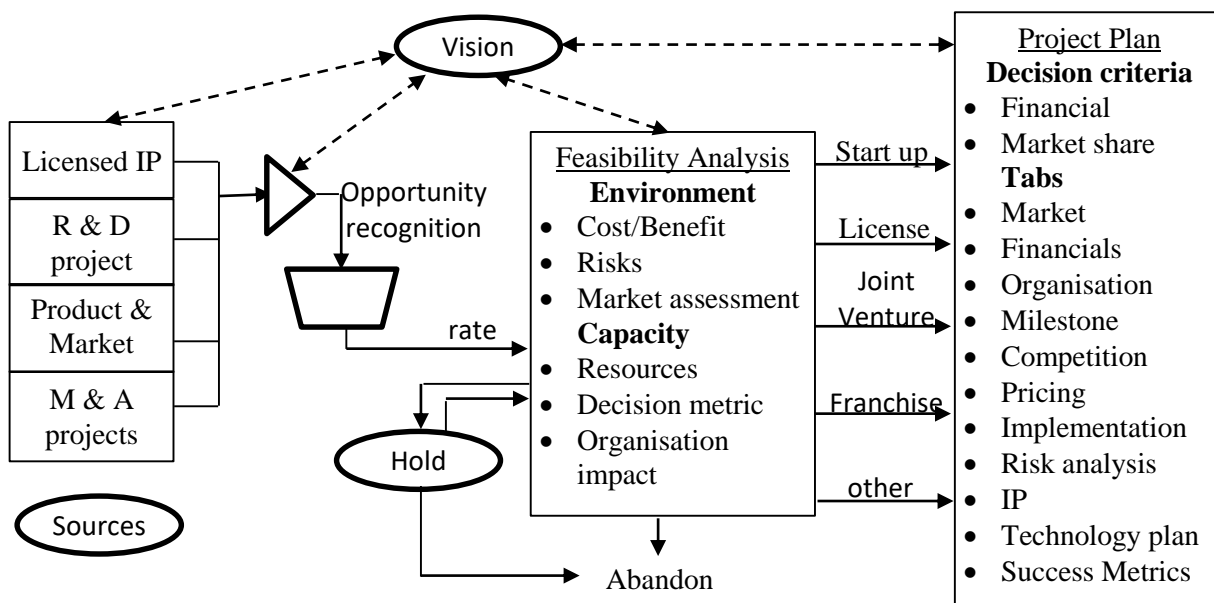


Figure 2. 2: Schaufeld's Commercialisation Model

Source: WPI (2017)

Schaufeld framework highlights five critical stages, where each stage sequentially leads to the next. Failure in any of the stages cripples the realisation of commercialisation. One stage is the sources of ideas. These include licensed IP, research and development and so on. The second stage is vetting of ideas for adaptation and deciding whether it poses an opportunity for the organisation. The vetting has to consider the organisation's resources and the ability to pursue the idea all the way to a commercial product. The third stage is feasibility analysis, where the selected idea is assessed against for possibility of success in the market. The framework acknowledges that not all ideas have equal chances of success. The market niche, costs, returns and other parameters

that are influenced by the market are assessed. Then fourth stage is considering the commercialisation pathways. These include start-ups, licensing, joint venture and other possibilities. The fifth stage is project planning. These includes identifying the exact critical market, customer preferences, pricing, marketing, competition and much more. Having identified such needs, the product can now be developed and rolled out.

2.7.3 The Integrated commercialisation model by Malec, Stanczak and Ricketts

Malec et. al (2020) developed an integrated commercialisation model of research and development projects' results. It was developed based on the authors' descriptions of six case studies. Of the six cases, three were successful projects and three were failed projects. This model compared financing principles, initiators, innovators, collaborating institutions as well as partnering industries, work plans, agreements, fees number of implementations in a project and much more.

The model emphasises that for a project to stand a chance of commercialisation there is need for clear understanding of the industry partners' expectations, needs and their legal and formal requirements. It is also critical for project managers to make sound realistic decisions. Other factors such as management of quality, risks, changes, correct planning and evaluation were identified as critical to the success. It also points out the research institution bares most of the processes with other processes such as production and monitoring being conducted by the partners. The research institution processes include innovation and strategy development.

2.8 Knowledge gap

Much research has been undertaken in areas such as promotion of innovation, enhancing partnership and collaboration in research and innovation, role of collaboration and partnership in research and innovation. While few studies have been conducted in the

realm of research commercialisation, thus focusing on how research outputs could be converted into viable commercial products and services, there are no studies in regard to how TVET institutions could commercialise their innovations in technology fields. This particular knowledge is lacking.

It was envisaged that this study had to generate knowledge that shed light in the field of innovation commercialisation. This was achieved through exposing inhibiting factors to bridging the interface between innovation and commercialisation of innovative technology products and services in TVET institutions. Further, it was expected that there could be shortfalls inherent in the practices of TVET institutions towards commercialisation of their technology innovations.

From review of literature on commercialisation models, studies have formulated different models, which are tailored to different fields of their concern. So far, no model is available for commercial realisation of innovations in TVET institutions in Kenya. This leaves TVET institutions at liberty to pursue any of the existing models or just to grapple in the dark and hope for the best. This situation has borne little or no significant fruits.

These bottlenecks, orchestrated by the approaches adopted by TVET institutions in conducting their daily practices could be hampering the realisation and promotion of commercialisation of innovations. Such issues had not been researched and documented in a direct manner as it has been set out in this study.

2.9 Chapter summary

It was clear that commercialisation of innovations provided an important avenue to harness the power of emerging technology solutions which could lead to technical institutions playing a major role in economic development of a country as well as

generate sustainable revenue for the institutions. For TVET institution to do this, they need a structure in their organisation that provides a framework that deliberately and systematically advocates for commercialising technology innovations.

CHAPTER THREE

RESEARCH DESIGN AND METHODOLOGY

3.1 Chapter overview

This chapter contains the systematic execution undertaken by this study as regards to data collection and analysis techniques. It outlines the research philosophy, population, sampling techniques, research instruments, validation and reliability of research instruments. It also focused on data collection methods and data analysis methods as well as ethical considerations of this study.

3.2 Philosophical Paradigm

This study subscribed to a pragmatism philosophy in research. The research investigated the workability of TVET practices in achieving the commercialisation phase of innovations in a TVET environment which is inseparable from the external players whose influence cannot be ignored. The ideologies of a pragmatist attach great emphasis on the practicability of actions in providing tangible consequences that are beneficial to the community. The pragmatism philosophy informed this study, in that it believes inquiries for generating knowledge are a process and have to be conducted within rules and guiding principles.

It is based on the principle that the usefulness, workability, and practicality of ideas, policies, and proposals are the criteria of their merit (Thayer, 2020). For an innovator in a TVET institution to successfully commercialise his or her innovation, there has to be interaction between the innovator and many other aspects such as existing technologies, target market segment, funders or sponsors, standards regulatory bodies and many others. Interaction is both at the institution level and at the larger community level. A pragmatic approach was therefore well suited for this research because TVET institution

and their innovators had to understand the prevailing circumstances in the world or their societies in order to successfully commercial their products. Such an understanding is the foundation of pragmatism as it advocates the knowing of the world as inseparable from agency within it (Stanford University, 2020).

3.3 Research design

This study adopted a descriptive survey research design. This design enabled the study to examine what is the prevailing situation in several TVET institutions with regard to commercialising their innovations. As a descriptive survey, the findings described what was happening under the prevailing situations by seeking responses of a broad number of issues regarding the subject matter. A further characteristic of a descriptive survey in this study, was that the research neither had control nor influence over the variables that were assessed. The study should not be in a position to influence or alter the set up during the period of the study. This was a key consideration in order to obtain credible findings in this study and therefore uphold the tenets of a descriptive design.

The study sought to collect the opinion from many participants in a wide geographical location about particular issues (Walliman, 2011) specifically the need to commercialise the many innovations that are being invented and developed in the TVET institutions which was in-line with descriptive surveys. The study does not intervene to alter the variables in any way rather was concerned with a specific research problem as it exists in the population of study. Therefore, the quality of this study was highly dependent on the choice of a descriptive survey as its design methodology (Carroll, 2014). Since participants' opinion and observations were to be quantified, a descriptive survey was deemed to be suitable as it provided a way of quantifying such measurements (Creswell & Creswell, 2017).

As a descriptive survey, the study did not specifically narrow down to a specific case and study it in-depth but rather it studied various cases and capture the main characteristics of these several cases in the wider population and within a reasonable depth. This research design was suitable in gearing the study towards providing answers to questions such as what is the current situation, how is the situation other similar questions.

Furthermore, a descriptive survey design was found to be appropriate in answering questions that deal with: who, what, when, where and how, that are associated with a particular research problem (University of Southern California, 2012). The particular problem in this study being the practice in TVET institutions regarding commercialisation of their innovative technology solutions as they exist at the time of the study. This study did not try to establish the cause-and-effect of observed attributes and as such it embraced the tenets of a descriptive survey.

It is worth noting that a descriptive study cannot conclusively provide answers to questions such as why institutions have particularly low rates of commercialisation of innovations as it existed at the time of the study. This design could only be used to obtain information concerning the current status of commercialising innovations and to describe "what exists" with respect to variables or conditions in such a situation. Furthermore, this design was found to be suitable given that the cases of study were observed in a completely unaltered natural status and as a pre-cursor to more quantitative designs (University of Southern California, 2012).

In other similar studies descriptive survey has been used successfully to study issues regarding innovations. One of such studies was conducted by Kithae et al (2014) to determine the impact of TVET institutions as drivers of innovative skills. The study assessed the current situation at the time on the applicability of relevant skills acquired

by TVET graduates in driving their TVET related enterprises. Descriptive studies have also been used in identifying characteristics of observed phenomenon or exploring the possible correlation amongst two or more phenomena.

3.4 Research study area

This study was conducted in Kenya. It covered selected TVET institutions across the country and aimed to understand the situation as it existed in the country. TVET institutions in Kenya are always encouraged to innovate in areas of technology. The institutions are given equal chances to showcase their innovations as well as compete amongst themselves. It was also noted that there were no studies indicating that certain regions in the country were more innovative than others. In that connection, no particular regions were given special priorities over others.

In that regard, this study focused on selected TVET institutions in Kenya. The situation under investigation was affecting the entire country. The study area has a sizeable citizenry, diversified population and had a wide variant of socio-economic activities endowed with natural resources which can be supported by innovative technology solutions. Different regions in the country face both unique and common challenges that the TVET institutions attempt to address with an innovative technology approach.

Moreover, TVET institutions across the Kenyan nation receive trainers from almost the same crop of graduates. This makes them have almost similar characteristics in terms of training. These trainers are the persons who later turn out to be innovators in these institutions that are distributed across the country. However, different exposure levels of trainers and unique working environment within the TVET institutions get to influence both their level of innovativeness and their drive to commercialise their innovations.

3.5 Target population

This study focused on public TVET institutions. These institutions receive public funds for innovations and by these funds, they are expected to innovate and commercialise their innovations through structures that may protect their products such as the Kenyan Intellectual Property Institute (KIPI) and other institutions such as KENIA which may sponsor such initiatives. These institutions were selected because they are tasked, at the very least, with the mandate to support the economic development of their localities through technology innovations among other roles. Therefore, the study's population consisted of public TVET institutions. Kenya Industrial Research Development Institute (KIRDI) also plays a significant role in supporting innovators in the field of engineering as well as developing their innovations into market viable products.

It is noteworthy that not all TVET institutions are actively engaged in developing innovative technology solutions. In spite of this, a good number of them are competitively successful in technology innovations as seen by the NACOSTI ranking of their products. The TVET institutions that formed this population were those which actively involved themselves in technology innovations and had been showcasing their products in the National Science Week that is organised by NACOSTI. Innovations designated for showcase in national exhibition are those that have been assessed and ranked as the best by expert judges in their respective disciplines.

The study was interested in such innovations for reasons that they have been polished to final products and in addition, they had received more funding from their institutions. Similarly, innovators behind these innovations have had sufficient time to develop their products. More so the products have competed and emerged as winning designs at both regional and national competitions. Thereby earning their places as ranked highly in innovations at the national science exhibitions. The study therefore believed that such

innovations have a greater potential to be commercialised. The study assumed that the zeal exhibited by innovators of TVET institutions in competitions reflected their eagerness to drive their innovations to the next level which is to have them commercialised.

Therefore, these institutions were identified from the NACOSTI or Kenya Association of Technical Training Institutions (KATTI) ranking lists of National Science exhibitions that dated from the year 2012 to 2019. This period marked the rebirth of technology exhibitions which had dwindled in the previous years. The exhibition was revamped and re-established in the country in order to encourage innovators to showcase their works. The institutions that comprised the target population are listed in Appendix VIII. A total of thirty TVET institutions were found to meet the criteria of being actively involved in technology innovations and had also presented technology innovative solutions that had been ranked top in the NACOSTI or KATTI ranking in National Science Exhibitions. As such, these TVET institutions comprised national polytechnics and technical training institutions across the country.

Heads of departments (also referred to as heads of sections) concerned with innovation and its commercialisation were considered for the study. The heads were expected to provide important information on various efforts their departments had undertaken with regard to collaboration and partnerships in improving commercialisation of technology innovations. Members of the research committee in selected TVET institutions also formed part of the respondents. The study considered that these members demonstrated the culture or practices of the institutions in driving innovations and commercialisation of institutions' products and services.

In this study, innovators of technology products were a key component in that they conceived and created innovative products and services that had the potential to be

commercialised. It was through them that an institution demonstrated its ability to innovate and thereafter commercialise. In that connection, innovators in the selected public TVET institutions in Kenya formed part of the respondents. These innovators were sampled from various fields of engineering and technology. It is worth noting that trainees in TVET institutions form a key component in innovations as they also participate in innovative processes at the institutions. Their participation is often under supervision of trainers. Since the study dealt with the practices of the institutions only trainers in innovations were considered as innovators. For the period under study, it was deemed to be practically impossible for the study to locate trainees who had been participating in innovations at their institutions.

For the study to corroborate its findings, it was important that major players such as government organs that are involved in the drive to champion for commercial innovations in TVET institutions in Kenya be included. Therefore, the study drew part of its respondents from KIRDI which plays a vital role as a middleman. These respondents advise various innovators on issues related to innovations, funding, patent rights and much more. Other state agencies that were included were the KIPi and KENIA.

3.6 Sampling procedure

This study used purposive sampling and random sampling techniques in selecting participants for the study. Lead officers in government agencies and departments that spearheaded innovation and commercialisation were purposively sampled. They contributed to the research by undertaking a face-to-face interview.

Sampling of TVET institutions was restricted to those institutions that formed the target population as seen in appendix VIII. They were randomly sampled in order to provide unbiased and a representative sample. By striving to obtain an unbiased population, the

study ensured that it was as close as possible to representing the reality in TVET institutions. In this regard, the study therefore selected 30% of these institutions through a random sampling technique. A sample size of at least thirty percent is considered by many studies as the minimum number of cases for a reliable statistical analysis on the data (Cohen, Morris, & Morrison, 2007). Innovators in these sampled institutions were also randomly sampled and requested to respond to the questionnaire.

This sample, which yielded the number of respondents, was calculated using Krejcie and Morgan method. This method is resilient and takes into consideration important factors in establishing the sample size, such as the population size and confidence level (Cohen, Morris, & Morrison, 2007). Below is the Krejcie-Morgan formula used for calculating the sample size of individuals in the population (Krejcie & Morgan, 1970).

$$n = \frac{\chi^2 NP(1-P)}{e^2(N-1) + \chi^2 P(1-P)}$$

where n is the required sample size

P is the population proportion. For maximum sample 50% is assumed.

e is the margin of error. Also called the confidence level = 0.05

N is the population size from which the sample is drawn

χ^2 is the chi-square value and depends on the degree of freedom. It is given as:

$$= 1.96 \times 1.96 = 3.841$$

The formula was applied to determine the size of respondents as follows:

$$n = \frac{(1.96)^2 \times 126 \times 50\% (1-50\%)}{(0.05)^2(126-1) + (1.96)^2 \times 50\% (1-50\%)}$$

$$= 95.06 \approx 96$$

Table 3.1 gives a summary of the sample size as derived from the population size in the study. Out of the population size of thirty (30) TVET institutions, 9 were selected to participate in this study. These nine TVET institutions were estimated to have about 126 innovators. In-line with the application of Krejcie and Morgan's formula for sample size calculation, the study targeted to include at least 96 participants for purposes of responding to the questionnaire. With regard to the head of TVET institutions and heads of innovations, the study purposely sampled nine principals and nine heads of innovations.

Table 3.1: Sample size

	Population type	Population size	Selection Formular/method	Sample size
i)	Innovative TVET Institutions	30	30% of population	9
ii)	Innovators in sampled institutions	126	Krejcie and Morgan	96
iii)	Heads of institutions and heads of innovations	30	Purposive sampling for interviewees	18
iv)	Lead officers in government agencies	3	Purposive sampling for interviewees	3

3.7 Research instruments

This study employed a variety of instruments. These instruments were an interview schedule, a questionnaire, a document analysis and an observation guide. Top managers in strategic leadership positions with regard to commercialisation of innovations in TVET institutions were interviewed. These participants, by virtue of their positions, were considered as custodians to special knowledge and deemed to execute strategic actions which influenced activities in TVET institution level activities that were of interest to the study.

Questions items in the interview schedule were semi-structured in form, such as to allow as much information as possible to be captured from the interviewees (Kenneth & Bruce, 2011). Using follow-up questions based on the interviewee's response, the research probed for additional information. This information was to either seek clarification of answers or to dig for deeper explanations. The question items were in-line and arranged in the order of the objectives of the study.

The study used two sets of interview schedules. The first set (see Appendix III) was designed for lead officers in state agencies who were involved in supporting commercialisation of innovation in the country. The second (see Appendix IV) set was meant for heads of TVET institutions and heads of innovation in TVET institutions. Both tools probed on the state of TVET institutions with regard to commercialising their products.

A questionnaire was used to collect data from a larger and widely scattered sample of innovators in the TVET institutions. Therefore, this questionnaire was meant for innovators whose work results to innovative products with the potential to be commercialised. A questionnaire in this case was suitable in that the research could have had sufficient time to interact with each respondent on a face-to-face basis as it would have been time intensive.

The questionnaire (see Appendix V) was semi-structured such that both close-ended and open-ended items were posed to the respondents. This allowed the research to gather additional information, which enhance the depth of responses that the respondents deemed appropriate for this study. The items were grouped in terms of the themes of the study. This facilitated ease in the analysis of data.

In order to grade the response of innovators, close ended items in the questionnaire adopted a 5-point Likert Scale to measure the degree of responses to a question item.

Respondents scored their answers in such orders as: “Strongly Agree”, “Agree”, “Not Sure”, “Disagree” and “Strongly Disagree” which was then graded from 5 to 1 respectively. This was in-line with a common practice of using the Likert Scale in studies related to commercialization of innovation. It is also a suitable scale for collecting interval data in research.

In an effort to establish evidence of practices and collaboration in TVET institutions, this study employed a document analysis tool (see Appendix VI). This instrument was appropriate as it collected evidence of institutional processes and strategies. The study also required evidence of linkages that showed collaboration and partnership with external entities.

The documents that were of interest to the study included minutes of meetings of innovators and partners, application for patents if any, reports on efforts achieved in commercialising innovations, strategic plans for commercialisation of innovation and any other documents of related value that were presented to the research. This information was important for triangulation purpose as it assisted in verifying analysis resulting from the questionnaire and interview response.

An observation guide (see Appendix VII) was used to assess the commercial viability of innovations at TVET institutes. These were innovations that were accessible to the study during its period. This guide comprised a checklist prepared by the study and based on the guiding principles that were developed by the Queensland Government on assessing the commercial viability of an innovation. These guiding principles were adopted to suit this study. This tool has been highly applied across the world to assess innovations and has been standardised over time.

3.8 Validity of research instruments

One limitation of descriptive design is that, it is heavily dependent on instrumentation for measurement and observation (University of Southern California, 2012). In order to cushion this study from this shortfall, the research carefully selected and tested research instruments and question items. In addition, the instruments were tested in a pilot study in two institutions. Data received from these institutions was used as pilot study data and instruments were evaluated.

The face validity of items in research instruments was scrutinised by university supervisors and experts before being deployed in a pilot study. After filling the data collection instruments, respondents in the pilot study were asked of their opinion on the respective research instrument. The opinion sought was on whether the research instrument they have responded to is relevant, sufficient and seemed to address the general aspects of this study (Taherdoost, 2016). It is proposed by Taherdoost (2016) that validity be assessed by a dichotomous scale of “Yes” and “No” to indicate favourable and unfavourable respectively.

Similarly, content validity was ensured by conducting a wider review of literature so as to incorporate important tenets of the study objectives. This was further verified by university supervisors.

3.9 Reliability of research instruments

One measure of reliability of research instruments can be obtained by measuring the internal consistence of the instruments. This study relied on the omega (ω) co-efficient to measure internal reliability of its questionnaire (Sijtsma, 2009).

The omega co-efficient provides a much better test for internal consistency than other similar and popular tests. Omega co-efficient was preferred in this study, since it is

known that other tests such as coefficient alpha underestimates the true reliability unless the items are tau-equivalent (Deng & Chan, 2017). Omega co-efficient does not violate the essential-tau equivalent. More so, it works well in the presence of skewness and small samples (Trizano-Hermosilla & Alvarado, 2016). It provides a more accurate measure of internal reliability (Peters, 2014; Sijtsma, 2008). For the proponents of omega co-efficient, it is desirable to have a co-efficient range within 0.7 to 0.95.

Upon computing the omega co-efficient of reliability a value of 0.79 was obtained. This value was used as the basis of assessing whether multiple Likert-scale has increased inter-correlation amongst its test items. And based on the foregoing discussion, it was established that sufficient statistical inter-correlation existed amongst the test items. This range provided acceptable level of internal reliability as a few redundancies in items had been corrected.

3.10 Pilot Study

A pilot study was conducted in two TVET institutions. These institutions were selected by way of a random sample. The sample was drawn from the pool of the remaining subset of institutions in the target population. The importance of this pilot study was to provide the research with data that was used for instruments' validation tests. It was important to test the instruments of data collection in order to ensure that instruments of data collection for this study met the desired threshold of tests.

All the research instruments were subjected to test in this pilot study. Heads of institutions were interviewed and also asked to give their input and assessment of the items in the interview schedule.

The study also tested the document analysis schedule and the observation guide to see whether the two documents sufficiently capture relevant research information. In

addition, the research inquired for more insight from the respondents on the topic under study. This information played a critical role in refining the research instruments and sharpening the focus of the study.

3.11 Data collection procedures

Before embarking on a data collection exercise the research obtained an introductory letter from the Head of Department of Technology Education of University of Eldoret. This letter, which was addressed to NACOSTI and served the purpose of introducing the researcher and the study to NACOSTI. This provided the basis on which NACOSTI issued a research license to grant consent for the study to be conducted (see APPENDIX I:).

With the NACOSTI license granted, the study proceeded to inform the County Directors of TVET in the respective jurisdictions about the intended study. This was done by presenting a copy of the research license and an introductory letter (see Appendix II) requesting for consent and cooperation. Similar copies were also presented to principals of TVET institutions which had been sampled for the purpose of this study. These documents served to introduce both the study and the researcher to these heads of institutions. In addition, the documents provided more details about the nature and objectives of the study.

To further clarify the research to the respondents, the study prepared a letter of transmittal which outlined the specific objectives of the study, its significance as well as requested for cooperation from the respondents and interviewees (see Appendix III). This letter also served to assure the participants of the confidentiality of the information they were to provide. Primary data was then collected from respondents and available official documents by either a way of interview schedule, questionnaire, document analysis and observation guide.

3.12 Data analysis methods

The data collected was analysed by both descriptive and inferential statistics. The research screened the data before subjecting it to relevant analysis. This initial but crucial step in data analysis involved running pre-tests on data to check whether data obtained by questionnaire met different assumptions for particular tests (Research Coach, 2018). Outliers were removed to avoid distorted results in the analysis (RMUOHP, n.d.). Any data that did not meet the assumptions' requirement was transformed using appropriate statistical methods and appropriate tests were performed (Crowson, 2019) as described in chapter four.

In addition, the research employed triangulation in analysis of data. This was achieved through comparison analysis of data gathered from different sources and by different research instruments. This approach served to collaborate research findings and thereby ensured truthfulness of gathered evidence that emanated from a variety of sources. This study optimised on the strengths of a mix of quantitative and qualitative research methodologies.

Research data that was gathered by questionnaire was analysed using descriptive and factor analysis techniques. Descriptive analysis involved frequencies, measures of central tendencies and dispersion (RMUOHP, n.d.). Responses that resulted from open-ended items in the questionnaire were reported qualitatively in the respective objectives in the findings. This was done in a narrative way to compliment the discuss in the sections. Data from observation guide was analysed descriptively. On the other hand, data gathered through interview and document analysis was triangulated with the questionnaire data and reported thematically as per the research objectives.

After analysis of the practices associated with the commercialisation of innovation in TVET institutions through descriptive analysis and correlation techniques, the proposed

model was developed. Exploratory factor analysis was used in the development of a commercialisation model of TVET innovations, which is the fourth objective of this study. Factor analysis reduced several variables in the study into fewer factors of significant influence. This assisted in extracting the common variance between factors that were most influential in bridging the gap to commercialise innovations. As a result, the underlying variables, or factors, that explain the pattern of correlations within the set of observed variables were exposed. A cross-tabulation was employed to show the impact of one aspect on the other.

3.13 Ethical considerations

This study complied with the standard practices of ethics in research. The study strived to uphold the principle of informed consent and utmost respect for institutions and individuals participating. Confidential treatment was accorded to all data collected from various sources as well as to all participants of the study. Institutions participating in the study were coded using numerical values and no names of institutions were written against their respective responses. Likewise, individuals, such as innovators, were assigned a numeric code hence no actual or real names were used in their responses.

Both numeric codes assigned to institutions and individuals respectively, continued to be used in analysis and reporting of findings of the study. The research did not use any collected data or information that had been generated in the process of the study to the detriment of the participants. This was clearly stated in the cover letter and in a brief section in the questionnaire and interview schedule. This assisted in reassuring the participants of confidentiality and thereby facilitated in gathering truthful information.

The preamble section of the questionnaire requested the participants to wilfully participate in the study. The study did not coerce any would be participant to participate

against his/her will. Participants were accorded a right to terminate their participation at any time (Walliman, 2011).

A research license granted by NACOSTI was sought before this study commences data collection. This license served to verified that the research was designed in an ethical manner and was fit to be conducted on the population and geographical region as concerned. Moreover, the managers of the institutions and TVET Counter Directors were informed of the study and a copy of the research license was given to them. Their consent to conduct the study within their jurisdiction was sought as well.

3.14 Chapter summary

A research philosophy based on a pragmatic approach guided this study. The study covered TVET institutions in Kenya. Relevant government agencies and/or departments and randomly sampled TVET institutions participate were selected to participate in this study. The respondents comprised the heads of institutions/departments who deal with innovation. The study respondents also included randomly sampled innovators in the sampled institutions.

In order to gather the relevant data for the study, an interview schedule, a questionnaire, document analysis guide and an observation guide were deployed. These instruments were validated in a pilot study and their reliability tested with an omega co-efficient measure. An authority to conduct this study was sought from NACOSTI Kenya. Data gathered in the main study was analysed using both descriptive and inferential statistical methods such as percentages and factor analysis techniques. The study observed standard ethical practices of research by abiding to ethical principles and regulations laid out by research authorities and government agencies.

CHAPTER FOUR

DATA PRESENTATION, ANALYSIS AND INTERPRETATION

4.1 Chapter overview

This chapter dwells on data presentation, analysis and interpretation based on the data that was gathered for this research. Presentation, analysis and interpretation is organised in-line with the objectives of the study. Firstly, it discusses the response rate and background information on respondents. Secondly, it presents the data analysis in a thematic order as per the objectives of the study. Thirdly, it presented the underlying factors that resulted to the derived model of commercialisation. The model is presented as well. Analysis of data presented in this chapter, unless stated otherwise, was performed using statistical tools available in SPSS 23 software package.

4.2 Response rate

This study employed several instruments in collecting data. The response rate of these instruments has been tabulated in table 4.1.

Table 4.1: Response rate

Entity	Actual Sample		Response		Minimum desired sample
	N	Percent	N	Percent	N
i. TVET institutions	9	100.0%	9	100.0%	9
ii. Heads of TVET institutions	9	100.0%	9	100.0%	9
iii. Lead officers in government agencies	3	100.0%	3	100.0%	3
iv. Heads of research and innovation in TVET institutions	13	100.0%	11	84.6%	9
v. Innovators in TVET institutions	123	100.0%	99	80.5%	96

From table 4.1, nine TVET institutions that were randomly selected to participate in this study did participate. This gave a response rate of 100%. Similarly, nine heads of these institutions, three lead officers of government agencies and thirteen heads of research and innovations in TVET institutions were interviewed. This was in-line with the computed minimum sample size.

For heads of research and innovations, the expected sample size was surpassed. This was necessitated due to some institutions having split research, innovation and commercialisation into several sections or units which were headed by different heads. Although the study anticipated to interview nine of these heads, where several such departments existed, the research had to interview other heads of these related units in order to obtain as much information as possible to enrich this study. As a result, there were thirteen heads of departments and the study managed to interview eleven of them. As pertains the TVET innovators the study sampled 126 against the minimum sample requirement of 96 innovators. These innovators were requested to respond to the questionnaire. Ninety-nine (99) of them managed to fill the questionnaire in a satisfactory manner. The remaining questionnaire were either not returned or had a lot of unanswered question-items rendering them unsuitable for analysis. The study noted that the response was above the required minimum sample for each set of instruments. The response generated was then analysed and its findings presented and discussed in this chapter.

4.3 Background information of respondents

The first section of the questionnaire sought to obtain information about the background of innovators that is related to this study. Such information included, professional experience, number of years they have practiced in innovation, how many innovations they have created within the said period and much more. Innovators background in

matters of innovation was regarded as crucial since period and activities within this period exposed the innovator to issues such as patenting, robust partnership, knowledge on possible funding sources and other avenues for commercialising their innovations. Descriptive statistics, which included measures of central tendencies and dispersion (Kometa, 2015) , was used to analyse data on respondents' background. The resulting analysis is presented below.

4.3.1 Relevant experience possessed by TVET innovators

Information regarding the background of innovators was tabulated in table 4.2. This included number of years the trainer had accumulated in participating in technology related innovative activities, total number of technology innovations which the innovator had developed as well as the number of innovations that had been commercialised.

Table 4.2: Respondents' experience in innovations

Experience in innovations	N valid	Std. Deviation				
		Mean	Median	n	Minimum	Maximum
i. Number of years participating in technology innovations	99	6.44	5.00	4.47	2.00	27.00
ii. Total number of innovations developed by the innovator	96	3.54	3.00	2.56	1	12
iii. Number of commercialised innovations	96	1.35	1.00	1.69	0	10

As indicated in table 4.2, ninety-nine (99) innovators responded to the question on the number of years they have participated in innovations. The calculated average was 6.44 years in innovations. Given a median of 5.00, it implies that most innovators had less than 6.44 years participating in innovations. Furthermore, a standard deviation of 4.42 with a range of 2 to 27 years and given a mean of 6.44 indicates that the innovators'

years of experience could be lower and widely varied. Thus innovators exhibit moderate experience in innovations with just a few of the innovators having long experience in innovation related matters.

It can also be observed that 96 innovators responded when asked to state the number of innovations they had. The average of this was found to be 3.54 products with a median of 3.00 against a standard deviation of 2.56. These values indicated that most innovators had innovated just about 2 to 3 technology solutions, given the value of the median.

The innovators responded questionnaire item that asked on the number of commercialised innovations they had created since they began to innovate. Ninety-six (96) of the innovators responded. It was established that the mean, median and standard deviation of the number of innovations were 1.35, 1.00 and 1.69 respectively. This low numbers of commercialised innovations pointed to underlying challenges that face TVET institutions in their attempt to commercialise innovations.

From interview proceedings it was noted that even though innovators claim that some innovations have been successful, it is just a perception or one-time sale under unstructured mechanism. From the interviews with heads of sections and institutions it was realised that innovators have occasionally managed to sell a few of their innovations. However, such sales have taken place in unstructured manner, such that even the institutions at times may not be aware of them. However, it was noted that once in a while some impressive innovations might attract orders but due to internal financial challenges or lack of dedicated processes to produce items needed in good time and in the numbers requested such orders end up unanswered. Not even an effort might be made to produce the ordered items.

4.3.2 Relevant experience of TVET innovators in terms of years as categorised in groups

The study also considered it important to determine experience of innovators in TVET in terms of their years in participating in innovations. This data on experience was categorized in intervals of 5 years. The findings are presented in table 4.3 below:

Table 4.3: Experience of TVET innovators categorised in group

Relevant experience of TVET innovators in the field of innovation and commercialisation		Valid	Cumulative	
		Frequency	Percent (%)	Percent
i.	Less than 5 years	39	39.4	39.4
ii.	Five to less than 10 years	42	42.4	81.8
iii.	Ten to less than 15 years	11	11.1	92.9
iv.	Fifteen years and above	7	7.1	100.0
Total		99	100.0	

It can be seen that a majority of innovators had experience of between 0 and 10 years in innovations whereas only 18.2% have more than 10 years in innovation and commercialisation. This raises concern because it could imply that innovators with more years of experience could be dropping out of activities that are directly related to innovation and commercialisation. This poses a challenge in that very little experience goes into developing an innovation with a commercial character. As noted by Malec et al (2020), experience is key ingredient in innovative entrepreneurship. It shapes the innovative culture of an organisation. Experience also plays a key role in enabling innovators to identify business opportunities.

4.3.3 Level of academic qualification of TVET innovators

The level of academic qualification possessed by the innovators in TVET institutions was found to be as follows: 3.0% (3) had certificate, 4.0% (4) had diploma, 9.1% (9) had higher national diploma, 58.6% (58) had bachelor degree, 19.2% (19) had master's degree and 6.1% (6) had a doctorate degree. This is tabulated in table 4.4.

Table 4.4: Highest level of academic qualification

Level of academic qualification possessed by the innovators	Frequency	Valid Percent (%)	Cumulative Percent
i. Certificate	3	3.0	3.0
ii. Diploma	4	4.0	7.1
iii. Higher diploma	9	9.1	16.2
iv. Bachelor degree	58	58.6	74.7
v. Master's Degree	19	19.2	93.9
vi. Doctorate	6	6.1	100.0
Total	99	100.0	

From the table, it is seen that a majority, 58.6% (58) of innovators have bachelor's degree in their area of specialisation. It is also seen that the other cadres are evenly distributed. These implies that innovators bring on board varied levels of academic capabilities and training which could be harnessed in a team basis with an aim of enhancing commercially geared technology innovations. This finding is in-line with a similar study by UNDP (2022) that acknowledged that staff in innovation labs in Kenya had good academic qualification.

4.3.4 Other relevant qualification(s) or training in innovations

The study sought to determine whether innovators have undertaken training in innovations. This aspect is important as such trainings assist in shaping skills in the area

of specialisation. More so these kind of trainings are often conducted by experts, hence are more likely to disseminate and equip innovators with unique skills necessary for competent innovations. Innovators were asked to list trainings they have attended with regard to innovations and also state the duration of the training. The responses were categorised into three: basic training, moderate training and advanced training. Table 4.5 tabulates the findings.

Table 4.5: Other qualification(s) or training relevant to innovation

Possession of other qualification(s) or training relevant to innovation		Frequency	Valid Percent (%)	Cumulative Percent
i.	None	71	76.3	76.3
ii.	Basic training - less than two weeks	15	16.1	92.5
iii.	Moderate training - two to four weeks	7	7.5	100.0
iv.	Advanced training – more than four weeks	0	0.0	100.0
Total		93	100.0	

It can be observed that most innovators, 76.3% (71) had no training in innovations. On the other hand, 16.1% (15) had undertaken training that lasted not more than two weeks. It was also noted that 7.5% (7) had moderate training which lasted for two to four weeks. None of the innovator had attended an innovation training lasting more than four weeks. From open-ended items in the questionnaire, the study found that some of the basic trainings attended in innovations included: computer simulations, proposal writing, artificial intelligence, CNC milling, 3D printing, software programming, AutoCAD and packaging technology. For moderate training the study identified innovators having attended the following areas: robotics, embedded systems, computer aided design, artificial intelligence and industrial processes. It was noted that although the above

trainings may assist innovators to come up with innovations, they may not really train innovators on how to design or develop innovative solutions.

One of important tenets of successful innovations is frequent training in innovative methods and practices. This makes it easier for technology solutions to transit from innovative phase to commercialisation phase. It is worthy to note that such trainings serve as means of sensitisation, aimed to inform the innovators of the prospects of commercialisation. Furthermore, information sharing and collaboration may be established and enhanced as a result of stakeholders converging for the training.

4.3.5 Possession of training in commercialising innovations

The innovators were also asked whether they had training in commercialising innovations. Their responses were as tabulated in table 4.6.

Table 4.6: Training in commercialising innovations

Training in commercialization of innovation	Frequency	Valid Percent (%)	Cumulative Percent
i. None	77	81.1	81.1
ii. Basic training - less than two weeks	18	18.9	100.0
iii. Moderate training - two to four weeks	0	0.0	
iv. Advanced training – more than four weeks	0	0.0	
Total	95	100.0	

It was realised that most innovators, 81.1% (77) acknowledged that they had no training in commercialising innovations. On the other hand, 18.9% (18) and 0.0% (0) had training lasting less than two weeks and two to less than four weeks respectively. It was noted that none of the innovators reported a training that lasted more than two weeks. As established, majority had no training in commercialising innovations. The implications of lacking such training is that it creates a bottleneck in the ability of innovators to focus their innovative efforts to the ultimate goal which is to

commercialise TVET technology innovations. This challenge was also noted by UNDP (2022) that academic innovative laboratories in Kenya had staff with good academic background but there was dire need to equip them with knowledge in innovation commercialisation skills. This UNDP study also revealed that there was limited number of trained staff to manage innovation processes.

4.4 Use of external technology in strengthening own innovation

In order to address this theme, several attributes were investigated. These attributes sought to establish the degree to which the selected TVET institutions strengthen their innovations by use of external knowledge and external technology. Questions relating to this objective were asked in the questionnaire and interview schedule. Table 4.7 presents the findings. In the table, SD stands for Strongly Disagreed, D for Disagreed, NS for Not Sure, A for Agreed and SA for Strongly Agreed.

Table 4.7: Use of external technology in strengthening own innovations

Attributes for use of external technology in strengthening own innovations	SD (N)	D (N)	NS (N)	A (N)	SA (N)	Total (N)
i. Institution evaluates and acquires intellectual property rights for use in internal innovations.	6.1% (6)	9.2% (9)	12.2% (12)	49.0% (48)	23.5% (23)	100.0% (98)
ii. It is important to consider market segment when innovating.	2.0% (2)	2.0% (2)	6.1% (6)	38.4% (38)	51.5% (51)	100.0% (99)
iii. Institution has a committee for commercialization of innovation.	6.1% (6)	28.3% (28)	32.3% (32)	25.3% (25)	8.1% (8)	100.0% (99)
iv. Institution has a business strategy for most innovative products.	14.1% (14)	26.3% (26)	30.3% (30)	25.3% (25)	4.0% (4)	100.0% (99)

v. My innovative products have aesthetic looks to make them more viable.	0.0% (0)	5.1% (5)	11.1% (11)	62.6% (62)	21.2% (21)	100.0% (99)
vi. There is viability of products against cost of production.	6.1% (6)	6.1% (6)	23.2% (23)	49.5% (49)	15.2% (15)	100.0% (99)
vii. There exist challenges in drafting agreements e.g. M.o.U. with partners.	5.1% (5)	6.1% (6)	25.3% (25)	43.4% (43)	20.2% (20)	100.0% (99)
viii. Innovations are market-need driven.	2.0% (2)	7.1% (7)	9.2% (9)	42.9% (42)	38.8% (38)	100.0% (98)
ix. Institution rewards commercially viable innovations.	11.2% (11)	26.5% (26)	29.6% (29)	23.5% (23)	9.2% (9)	100.0% (98)
x. Institution has a practice that innovation must have quality production for profit.	3.0% (3)	12.1% (12)	21.2% (21)	50.5% (50)	13.1% (13)	100.0% (99)
xi. There exists a practice for innovations to be demand driven.	7.1% (7)	12.1% (12)	16.2% (16)	44.4% (44)	20.2% (20)	100.0% (99)
xii. Institution holds frequent meetings on innovation and commercialization.	10.1% (10)	24.2% (24)	28.3% (28)	25.3% (25)	12.1% (12)	100.0% (99)

These findings have been discussed in the sub sections that follow. It has been arranged as presented in table 4.7 on use of external technology in strengthening own innovations.

4.4.1 Evaluation and acquisition of intellectual property rights for use in internal innovations

Acquisition of intellectual property rights for purposes of enhancing internal innovation processes is essential to any institution or organisation that wishes to commercialise its innovations. IPR enables innovators to incorporate technology that would otherwise be out of their reach. By thoughtfully considering external technologies and acquiring the needed technologies, TVET institutions can significantly reduce their lag time in coming up with innovations. Importantly, the number of IPR uptake can serve as a measure of organisation's effort to innovate.

Innovators in TVET institutions were asked to state whether their institution evaluates and acquires intellectual property rights for use in internal innovation. Their response is presented in table 4.7. The response indicated that 15.3% (15) disagreed, 12.2% (12) were not sure while 72.5% (72) agreed. This finding implied that TVET institutions acknowledge the significance of IPR acquisition. This was collaborated by responses from interviews held with lead officers of government agencies. These officers stated that their agencies have held joint sensitisation meetings and training with TVET institutions regarding IPR. This had been achieved through invitations from institutions and agencies' own initiative.

Furthermore, it was evident from analysis of documents that most TVET institutions had established an IPR officer and had an IPR policy or guidelines while a few others were still developing the policy. However, it was also noted that the IPR policy in these institutions were not as vibrant as they should be. This was evident in little documentation available to support their activities. This finding echo a similar observation by Lugasi and Odhiambo (2022) on implementing Technology and Innovation Support Centres (TISCs). They found that prioritisation of intellectual property by institutions was rare and further attributed this to ignorance among innovators.

Heads of institutions also noted that through the Memorandum of Understanding (MoU) between TVET institutions and partners, TVET institutions get access to technologies that would otherwise be out of their reach. This is in line with sentiments of Carroll (2014) that organisation should not be constrained to only using internal knowledge to develop its products but should open up to infusing external knowledge and technology as well.

4.4.2 Consideration of market segment when innovating

As illustrated in table 4.7, it is agreed that, it is important to consider knowledge of the market segment when innovating. Knowledge from the market place helps one to know what the consumers' interest are as well as the gap within the market. It can be seen that 4.0% (4) disagreed, 6.1% (6) were not sure while 89.9% (89) agreed that it is important to consider knowledge of the market segment when innovating. This finding indicated that innovators at TVET institutions were cognisant to the fact that understanding the market segment was key to innovating a commercially viable product. However, a scrutiny of available documents in TVET institutions did not indicate activities related to market survey before undertaking innovative projects.

By exploring and targeting the existing market niche, innovators are able to come up with opportunistic products that are customised to meet specific needs of a market subset, thereby raising the chances of finding ready market. This lowers the overhead costs in marketing activities, costs that TVET institutions may not be well endowed to afford. As note by Farhana and Swietlicki (2020), start-ups can be quite successful and quickly gain consumer acceptance if they explore niche markets with breakthrough innovations.

4.4.3 Existence of a commercialisation of innovation committee.

The availability of a commercialisation committee in an institution serves to boost the impetus of the institutions to actively pursue this goal. With intent to commercialise innovations, the committee has to formulate different avenues to achieve this goal. The committee has to provide advice and recommendations to innovators on how to incline

towards the business angle. It then strives to put in place both resources and structures that are necessary for commercialisation to be realised.

From table 4.7, it can be seen that 34.4% (34) of innovators disagreed, 32.3% (32) were not sure and 33.4% (25) agreed that there is a committee on commercialisation of innovation in their institution. This finding indicated that the innovators had mild awareness of the existence of such a committee.

Observation revealed that most TVET institutions are cognisant of the need to commercialisation their innovative products. They have set up income generating units (IGUs) or income generating activities (IGA) Units or business centres which bear responsibility of managing the commercialization of their products. However, as noted in the interviews and document analysis, most of these activities and market survey were not for technology innovations, but rather are for activities like baking bread, normal garage services, repair of common faults in machines and equipment, catering services, conventional farming and so on.

It was noted that TVET institutions had either persons and committees in-charge of units that deal with income generation in the institution. In some, these units were responsible for commercialisation of innovations that have the potential to generate income and that arise within the institution. However, such a technology innovation would be treated in a manner similar to any other project that would generate income. Therefore, innovators might seem not to have been aware of the mandate of such units in regard to commercialising innovations.

Definitely, the existence of such committees is worth appreciation, but it should be noted that the intricacies of commercialising a technology innovation is more likely to need much effort compared to conventional or regular projects that generate income. This

poses a risk in that technology innovations might be relegated to the margins and fail to receive the much needed push towards attainment of a commercial success.

4.4.4 Availability of business strategy for innovative products

The presence of business strategy was seen to be useful for most institutions with innovative products. A business strategy helps to give guidance on how resources are to be used in meeting the business objectives for innovation. It also helps to deliver value for competitive commercialisation. When asked to state whether TVET institutions have a business strategy with regards to technology innovations, it can be seen in table 4.7 that 40.4% (40) disagreed, 30.3% (30) were not sure while 29.3% (29) agreed. It was observed that majority, 70.7% (70) of TVET innovators either disagreed or were not sure. In the contrast, interviews carried out with heads of sections alluded to the existence of a sound business strategy for innovative products of TVET institutions. Therefore, this demonstrated that there was a disconnect in the business strategy that existed on paper and the actual pathway as conceived by innovators as most innovators were not aware of the business strategy. The creation of a sound business strategies is beneficial to guiding a business undertaking. This finding concurred with one stated by Lugasi and Odhiambo (2022) that some threats faced by Kenya in turning innovations to business ventures is the lack of entrepreneurial skills and ignorance amongst innovators.

4.4.5 Aesthetic looks of innovative products

Aesthetic value of a product gives an appeal and taste to a potential client. It can make a difference in the product's viability for commercialisation. When asked whether they incorporate aesthetic looks to their innovative technology solutions, innovators

responded as in table 4.7. It can be seen that 5.1% (5) disagreed, 11.1% (11) were not sure and 83.8 (83) agreed. This indicated that the innovators find it important to incorporate aesthetics in their innovative products with an aim to make them more viable for commercialisation.

This finding agrees with sentiments of Schummer et al. (2009). They pointed out that although it is difficult to measure the value of aesthetics in engineering products, it still remains an important consideration. It influences the pleasure or displeasure of an innovation product which also contributes to preferences. Aesthetic values include beauty, simplicity and elegancy among others.

4.4.6 Viability of products against cost of production

In coming up with innovations, TVET institutions need to consider the cost incurred in innovating a product. These are the expenses incurred and the monetary values of implementing various activities during the innovative development phase of the product. As tabulated in table 4.7, it can be seen that 12.2% (12) of the innovators disagreed, 23.2% (23) were not sure while 64.7% (64) of innovators agreed that the cost of innovations made the products viable for commercialisation.

It can be said that innovators who disagreed and those who were not sure, thus comprising 35.3%, had not actively oriented their innovative activities to the cost reduction approach to innovation. Hence, they were not conscious of the influence of cost of innovation in regard to the possibilities of commercialising their outputs. Chwastyk (2015) notes that due to market competitiveness, innovators and their companies must be aware of the cost implications that comes with choices of innovative solutions. It is paramount to make an informed choice in the face of limited funds. Costs

such as choice of tools, materials, processes, prototypes and external acquisitions among others.

4.4.7 Drafting of Memorandum of Understanding (MoU) with the partners

Table 4.7 shows responses of innovators on whether there exist challenges in drafting MoUs between institutions and partners. 11.2% (11) disagreed, 25.3% (25) were not sure and 63.6% (63) agreed that various challenges exist. It can be seen from the results above that most innovators expressed concerns over the challenge of realising a formal partnership with industry and other organisation when it comes innovations and commercialisation. This was reiterated by government agencies.

From the interviews with heads of institutions it emerged that MoUs were affected by unclear policies and continuous shifting of government and ministry guidelines. In addition, the study realised that another challenge is the duration between commencement and finalising of the MoU signing processes. It was noted that there was fear of the unknown when it comes to signing of MoUs. Some would be key partners just do not believe that TVET institutions have the capacity and therefore not worth to be in any partnership with them.

More so, some do not even respond to TVET institutions' request to formalise their engagement. Also different partners have different preferences, with some preferring to sign an agreement rather than an MoU. One head of institution even pointed out that some partners require institutions to commit themselves to indemnify the organisation in case of loss or damage to their equipment and staff. Such provisions are contrary to the guidelines of TVET institutions. The above finding is not unique to this study. It had been pointed out by Mustafa et al. (2022) who noted that unclear government policies

affect efforts to strike partnerships between vocational training centres and the industries.

4.4.8 Market-need driven innovations

The approach to innovations being market-need driven means that innovators focus their efforts to solving real-life problems in the community or nation. Innovators were asked whether their products were market-driven. It can be seen in table 4.7 that 9.1% (9) disagreed, 9.2% (9) were not sure whether the approach to innovation market is need driven. On the other hand, 81.7% (80) agreed that the approach to innovation was market-driven. In the contrary, it emerged from document analysis that little evidence exists to suggest that the innovative products address market needs. For instance, there were insufficient documentary evidence to suggest that market survey was carried out prior to the innovations were earmarked for development or user involvement in the development and refining of a product.

Innovations founded on market needs are a step in their success. A study by Malec et al. (2020) found that successful companies in commercialising innovations involve the user throughout the design process. Moreover, these companies collaborate with external partners in formulating new products. A study conducted in Kenya by Siringi (2022), emphasised the importance of focusing research outputs to the needs of the society. This creates an immediate impact and renders high market reception for the outputs.

4.4.9 Rewarding of innovators for commercially viable innovations

The respondents were asked whether innovators were rewarded by their institutions for coming up with commercially viable technology solutions. As illustrated in table 4.7, the study found that 37.7% (37) disagreed with the statement, 29.6% (29) were not sure

while 32.7% (32) strongly agreed. This response suggested that majority of them either were not sure or disputed existence of a practice that stipulates rewards for innovators who come up with commercially viable technology innovative solutions. It means therefore innovators believed that no financial gain could result from these activities. Such a belief would lower the overall motivation to innovate. This finding is in-line with the observations from interviews with government agencies that institutions have been lacking in rewarding promising innovations.

A study by Njine et al (2017) emphasised the practice of rewarding employees either financially or non-financially. It found a direct significant correlation between rewarding and employee engagement in innovation performance. This is critical in that employees, just like innovators will go out of their way to produce a much quality item since they will feel motivated to do so. Although RVTTI (2020) noted that TVET institutions have been exposed to some rewards for innovation, there is need to have rewards that specifically target successfully commercialised innovations.

4.4.10 Existence of a practice that emphasises quality production for profit

Having a policy or a practice that guides the quality of innovation helps the institution in that anyone with an innovation must come up with a quality product for profit. Findings on this attribute show that most innovators agreed that their institution emphasises quality production for profit. It can be seen in Table 4.7 that 15.1% (15) disagreed, 21.2% (21) were not sure whether the institution has a practice that innovation must have quality production for profit while 63.6% (63) agreed to it.

Although the innovators were cognisant of the practice, analysis of documents did not find a policy to support the sentiments of innovators. Moreover, an observation

conducted on available innovative products revealed that out of the forty-two (42) products seen by the research, seventeen (17) could be rated at being in a quality that can meet the market standards. These included innovations that were in a state that could be purchased and put into usage without undergoing further processes. Such items were farm machineries, household items and devices, seed varieties and power saving equipment.

The latter is in-line with a study by Omokungbe et al. (2023). The study observed that innovative products by TVET institutions do not receive much attention to be polished to the levels which cause them to meet market standards. It was noted that more often than not they remain in a prototype state and that all that will happen to them. This was evident in the innovative solutions that the research managed to access during the course of the study. Most of the innovations were still samples for demonstration of the working idea.

4.4.11 Existence of a practice for demand-driven innovations

Innovators in TVET institutions were asked whether there is a practice within their institutions, which promotes demand driven innovations. It can be seen from table 4.7 that 19.2% (19) disagreed while 16.2% (16) were not sure of existence of such a practice. On the other hand, 64.6% (64) agreed. Out of forty-two (42) projects available to the research, fourteen (14) demonstrated their uniqueness in terms of idea and functionality to meet market demands.

By tailoring their innovations to satisfy market demands, innovators in TVET institutions demonstrated the potential to conceive ideas and actualise them into reality. Demand driven innovations may be easier to turn into commercial products. This is

supported by a study by UNDP which noted that the policy environment in National Government of Kenya has adapted policies to support demand-driven innovations. Such policies included the Kenya Vision 2030, Africa Agenda 2063 and National ICT policy of 2019 among others (UNDP, 2022).

4.4.12 Frequent meetings in innovation and commercialisation

From 4.7, it can be seen that 34.3% (34) disagreed while 28.3% (28) were not sure whether their TVET institution held frequent meetings on innovation and commercialisation. On the other hand, 37.4% (37) agreed to it. Therefore, this finding indicated that although TVET institutions conducted meetings on innovations and commercialisation, such meetings were not as frequent in a way to stimulate the utmost desire to commercialise innovations. This is the reason why some innovators believe that such meetings on this subject were not frequent. However, from the interviews held, it was pointed out that regular meetings were held, in which matters pertaining innovations and commercialisation were discussed.

Meetings are critical in setting the tempo for commercialising innovations. It is in meetings that new issues, expectations, directions and timelines are discussed. Therefore, frequent meetings serve to enhance a culture that stresses and promotes the relevance of the matter in question. As stated by Chipperfield (2020), it is critical to maintain an agile culture that frequently upholds staff involvement such as meetings.

4.5 Value creation for internally developed innovations

The second independent variable that was regarded to influence commercialisation of technology innovative solutions in TVET institutions was the ability of TVET innovators and institutions to create value for their internally developed innovations.

Seven attributes were considered under this variable. Innovators response on creation of value for their internally developed innovations was tabulated in Table 4.8. In the table, SD stands for Strongly Disagreed, D for Disagreed, NS for Not Sure, A for Agreed and SA for Strongly Agreed.

4.5.1 Internal value addition to innovations

Table 4.8: Value creation for internally developed innovation

Attributes for assessment of value creation for internally developed innovations	SD (N)	D (N)	NS (N)	A (N)	SA (N)	Total (N)
i. Is internal value addition at institution affected by insufficient funding	8.1% (8)	10.1% (10)	6.1% (6)	41.4% (41)	34.3% (34)	100.0% (99)
ii. Institution has acquired rights to use intellectual property from external innovators	15.2% (15)	30.3% (30)	32.3% (32)	17.2% (17)	5.1% (5)	100.0% (99)
iii. The institution has sold some of Intellectual Property Rights to external innovators	17.2% (17)	25.3% (25)	42.4% (42)	11.1% (11)	4.0% (4)	100.0% (99)
iv. Availability of infrastructure for exploring ideas and obtaining feedback	13.3% (13)	32.7% (32)	4.1% (4)	33.7% (33)	16.3% (16)	100.0% (98)
v. The institution incorporates external research to add value to internal innovations	8.1% (8)	10.1% (10)	20.2% (20)	39.4% (39)	20.2% (20)	100.0% (98)
vi. This institution utilises internal Research and Development to add significant value to our innovation	0.0% (0)	9.1% (9)	10.1% (10)	65.7% (65)	15.2% (15)	100.0% (99)
vii. Institution's technical facilities have a positive influence in my effort/ability to commercial my innovation	4.1% (4)	7.1% (7)	18.4% (18)	52.0% (51)	18.4% (18)	100.0% (99)
viii. Innovators in this institution protect their ideas by obtaining a trademark, design right or patent.	5.2% (5)	8.2% (8)	11.2% (11)	49.0% (48)	26.5% (26)	100.0% (98)

Innovators in TVET institutions noted that insufficient funding was affecting internal value addition to innovations. It can be seen in table 4.8 that 18.2% (18) disagreed, 6.1% (6) were not sure and 75.7% (75) agreed that this was the case. This finding pointed out that it was challenging to upscale, modify or enhance already existing innovative solutions due to little funding that goes towards improving innovations. It is therefore a concern in TVET institutions. It is noted that a majority of innovators stated that insufficient funds affected contributed to low resources resulting to lack of improvements to their products. Arguably, funds are essential for the overall development of the supporting infrastructure and a supporting ecosystem. As a result, innovations continue to be trapped in the fruitless cycle of non-commercialisation.

4.5.2 Acquisition of Intellectual Property from external partners

It can be seen from table 4.8 that 45.5% (45) disagreed, 32.3% (32) were not sure whether the institution purchase intellectual properties from external partners and 22.2% (22) agreed. This means that TVET institutions were reluctant to purchase intellectual property rights from external partners. This is a general challenge faced by innovators worldwide. As pointed out by Malec et al (2020), innovators have a natural tendency of concealing essential information from other parties for fear of the other parties gaining a competitive edge based on the information.

4.5.3 Sale of intellectual property right to external partners

Innovators were asked whether their TVET institutions have managed to sale intellectual property rights to external partners. Majority of them responded that they were not sure that such arrangement does exist. From table 4.8, it can be seen that 42.4% (42) disagreed while 42.4% (42) consented to not being sure of any sell of intellectual

properties to innovators or organisations outside their institutions. On the other hand, 15.2% (15) agreed.

From interviews with heads of sections and government agencies, it emerged that institutions were encouraged to collaborate with external partners even in areas where they have such rights. It also emerged that sometimes it is difficult to prove originality of a number of innovations claimed in these institutions. Furthermore, a number of innovations end up not being patented and therefore no IPR exist for sale. This was also observed by (Siringi, 2022) that although there exist innovations by institutions in Kenya, very few have been protected or commercialised.

4.5.4 Availability of infrastructure for exploring ideas and feedback

The study sought to find whether TVET institutions have supporting infrastructure that enable them explore innovative ideas and obtain feedback. It can be seen in table 4.8 that 45.9% (45) of innovators disagreed, 4.1% (4) were not sure while 50.0% (49) agreed that TVET institutions have infrastructure such as workshops and innovative laboratories for exploring ideas and obtaining feedback. This is an indication that about half of the innovators did not have infrastructure that could boost their efforts in innovations and commercialisation.

Exploring new ideas, obtaining feedback and improving designs are important processes in developing a commercially viable innovation. An innovative infrastructure is an integral component in sparking and sustaining innovations and obtaining a market competitive edge (Jeffrey, 2016). This challenge in Kenya has been noted by Sweden among other countries. Sweden has partnered with United Nations (UN) Kenya to

provide funds to promote the realisation of Goal 9 of the Sustainable Development Goals (SDGs), which is industry, innovation and infrastructure (UN Kenya, 2022).

4.5.5 Incorporation of external research to add value to innovations

The world over both research and training institutions leverage on each other's strengths by trying "not to re-invent the wheel." By incorporating research from external partners and players, TVET institutions would cut down the cost of innovation and hence commercialisation. This could be incorporated through value-addition to already existing innovations. Such endeavours could assist institutions with tools to create products that meet quality standards at a much lower cost in terms of investment. These would increase their chances to maximise commercialisation of their products.

From table 4.8, it can be seen that 18.2% (18) disagreed, 20.2% (20) were not sure while 59.6% (59) agreed that their TVET institutions incorporate external research to add value to innovations. This finding suggests that innovators in TVET institutions strive to build on product and ideas already availed by external players. Similarly, it was established from interviews with concerned government agencies that Technology and Innovations Support Centres (TISCs) have been set up across Kenya to allow technology innovators to access scientific and technology information and publications from other works by researchers and innovators. However, as pointed out by Otieno (2021), innovators in Kenya lack the support from external sources that would upscale their innovations to the next level.

4.5.6 Utilizations of internal research and development to add significant value to innovations

Internal research and development comprise activities that are conducted within the institution with an aim of promoting value addition to already existing internal innovations. Most institutions utilise internal research and development to add value to their innovations, since it provides a more flexible environment. As seen in table 4.8, innovators response was that 9.1% (9) disagreed, 10.1% (10) not sure and 80.8% (80) agreed that the institution utilises internal research and development to add significant value to innovations.

From this finding, it is realised that innovators mostly utilise their internal research and innovation facilities to improve on their innovation. As such, these facilities need to be equipped with modern and sufficient tools that can facilitate the productive outputs in various fields. This practice serves as a quick way to carry out research in a self-customised environment despite making the process of innovation to be a bit costly.

4.5.7 Utilisations of technical facilities to improve technical innovations

Innovators were asked whether their institutions utilised their technical facilities to improve technical innovations. Their response was tabulated in table 4.8. As seen, 11.1% (11) of the innovators disagreed, 18.4% (18) were not sure while 69.7% (69) agreed that the institutions' technical facilities are utilised in improving innovations. This means that these facilities are significant and play a positive role in influencing innovators' abilities to innovate and the efforts to commercialise their innovations.

This finding paints a different scenario from that established by a study on the utilization of laboratories in skills acquisition by trainees, which observed that there is neglect

management and utilisation of electronic laboratory and equipment (Okemwa, Ferej, & Wanami, 2022). However, in Nigeria, one study found that TVET institutions had adequate workshops, ICT infrastructure and equipment to carry out their mandates and other endeavours (Akhueomonkhan & Raimi, 2013). Moreover, these adequate facilities were utilised to a greater extent to support TVET processes. Ojera et al. (2021) noted that utilisation of facilities and the role they play in skills development is critical. This holds true for trainees, trainers and innovators.

4.5.8 Protection of intellectual ideas

An institution protects its intellectual ideas by obtaining a trademark, design right or patents. Patent acquisition enables innovations to be claimed by their owners thereby preventing malicious duplications of the innovations by other industry players. Patents serve to guarantee the owners of monetary proceedings resulting from use and application of their technology or products. The number of patents owned by an organisation such as a TVET institution can serve as an indicator for gauging the level of innovativeness of an organisation.

From table 4.8, it can be seen that 13.3% (13) of innovators in TVET institutions disagreed, 11.2% (11) were not sure while 75.5% (74) agreed that they protected their ideas by obtaining a trademark, design right or patent. It therefore emerged that most innovators claimed to legally protect their intellectual property. However, a study by Siringi (2022) suggested that this was not the case. Similarly, government agencies when interviewed, observed that most original work by TVET institutions were not patented. One of the reasons cited was that innovators do not immediately realise the commercial potential of some innovations however simple or complex they seem to be.

4.6 Collaboration with external partners

The third objective in this study investigated the involvement of TVET institutions in collaborative engagements with external partners. Collaboration in this regard referred to matters related to innovation and its commercialisation. Several attributes were investigated to determine this influence to the efforts of commercialising TVET innovations. The attributes are presented in Table 4.9 and further discussed in this section. In the table, SD stands for Strongly Disagreed, D for Disagreed, NS for Not Sure, A for Agreed and SA for Strongly Agreed.

4.6.1 Active search for collaboration

It is imperative that TVET institutions actively search for collaboration. Collaboration helps in coming up with different ideas in the process of product innovation. It also eases the process of either acquiring resources or accessing them. From table 4.9, it can be seen that 13.2% (13) disagreed, 28.6% (28) were not sure while 58.2% (57) agreed that their institutions actively search for collaborators in their attempt to commercialise technology innovative solutions.

This finding indicates that more than half of innovators, 58.2% were in agreement that TVET institutions actively seek for collaborations. This supports the constructs in the conceptual model of commercialisation and patenting for universities in Kenya (Siringi, 2022). Active search for partners to promote collaborative engagements is deemed to be a critical endeavour for TVET institutions as it presents opportunities for trusted avenues of testing their innovations.

Table 4.9: Collaboration with external partners

Attributes for assessment of collaboration with external partners	SD (N)	D (N)	NS (N)	A (N)	SA (N)	Total (N)
i. The institution actively searches for collaborations	2.0% (2)	11.2% (11)	28.6% (28)	48.0% (47)	10.2% (10)	100.0% (98)
ii. Collaborators come by themselves to seek for our partnership	2.1% (2)	16.5% (16)	41.2% (40)	27.8% (27)	12.4% (12)	100.0% (97)
iii. In accepting collaboration, the institution considers: resource base, intellectual resources and funding ability of collaborators	5.2% (5)	5.2% (5)	25.8% (25)	46.4% (45)	17.5% (17)	100.0% (97)
iv. There is adequate partnership with industries with regard to innovating for commercial purpose.	14.1% (14)	19.2% (19)	37.4% (37)	23.2% (23)	6.1% (6)	100.0% (99)
v. Collaborators have brought critical resources to the institution	8.0% (7)	15.9% (14)	27.3% (24)	33.0% (29)	15.9% (14)	100.0% (88)
vi. Most innovators in this institution are creative.	0.0% (0)	4.0% (4)	8.1% (8)	51.5% (51)	36.4% (36)	100.0% (99)
vii. Most innovators in this institution are enthusiastic about commercializing innovations	0.0% (0)	12.4% (12)	14.4% (14)	49.5% (48)	23.7% (23)	100.0% (97)
viii. Most innovators in this institution are self-motivated to innovate.	0.0% (0)	6.1% (6)	4.0% (4)	53.5% (53)	36.4% (36)	100.0% (99)

4.6.2 Collaborators seeking partnership by themselves

TVET innovators noted that it was not clear whether collaborators seek partnership by themselves. From table 4.9, it can be seen that 18.6% (18) disagreed, 41.2% (40) were not sure and 40.2% (39) agreed that collaborators seek for partnership by themselves. From the interviews it emerged that a few partners come on their own but mostly the TVET institutions have to venture out and seek for them especially when opportunities such a research sponsorship presents itself. This finding is contrary to that of Malec et

al. (2020), who observed that companies interested in market driven innovations strive to collaborate at different levels with a view of coming up with different ideas and product.

4.6.3 Consideration for acceptance of collaboration

Do TVET institutions have key considerations which they prioritise before accepting collaboration with different partners? Considerations such as intellectual resources of the collaborative partners, which include patents and innovation ideas, financial resources such as the affinity to attract sponsorship, funding ability that influences whether a partner can fund the process or the product under development. It was realised as shown in table 4.9 that 10.3% (10) of innovators disagreed, 25.8% (25) were not sure while 63.9% (62) agreed that in accepting collaboration TVET institutions considered the strengths of the would be partner.

4.6.4 Adequate partnership with industries for commercialisation of innovations

It is one thing to form partnerships and another to utilise partnerships to the benefit of the institution. Innovators in TVET institutions were asked to state whether there is adequate partnership with the industries in regard to commercialisation of their innovations. From table 4.9, it can be seen that 33.3% (33) of the innovators disagreed, 37.4% (37) were not sure and 29.3% (29) agreed. In general, it was not clear to innovators whether TVET institutions had adequate partnership with industries with regard to innovation for commercial purposes.

This implies that there was no significant industry engagement with the innovators. It also implies that when MoUs are signed at higher management levels, very few transit into actual engagement for innovations. Ndemo (2015) while assessing Kenya's

effective innovation policies for development, came to a similar conclusion that there is a disjoint between the industry and research institutions when it comes to innovation activities.

On their part, the heads of institutions observed that the most common partnership formed is in training, curriculum development and implementation. They noted that only few partnerships are based on innovation and research. However, there were efforts in improving partnership with industry and manufacturing sectors in this line. It also surfaced that unclear government policies and guidelines in the recent past on how commercialisation should be pursued in TVET institutions constituted a bottleneck to this endeavour.

4.6.5 Collaboration and resource harnessing

Collaboration brings together parties with different ideas, expertise and resources. Then each party, through its ability strives to ensure that there are enough resources to accomplish the task at hand. In that connection, innovators were asked to state whether collaborators in innovations had brought critical resources to the institutions. It can be observed as tabulated in table 4.9 that 23.9% (21) disagreed, 27.3% (24) were not sure while 48.9% (43) agreed. It was therefore the opinion of most innovators that external collaborators had contributed to avail critical resources to TVET institutions. However, majority of innovators seemed not to have realised this contribution. This implies that TVET institutions and their partners need to enhance their contributions in a manner to effectively harness each other's potential. As noted by Tom and Mary (2021), TVET needs to be partnership based. Where TVET benefits from partners and likewise partners benefit from TVET. These partnerships engagements need to broaden and include planning, management and funding of TVET processes.

4.6.6 Creativity of innovators

Innovators were asked whether they believe they were creative in innovation and commercialisation. It is clear that creative works lead to unique innovations hence products that can be patented and commercialised. From table 4.9, it was established that most innovators in TVET institutions strive to be creative in their innovations. It was realised that 4.0% (4) disagreed, 8.1% (8) were not sure and 87.9% (87) agreed. It can be said therefore that majority of innovators were positive about being creative in innovations and commercialisation.

This was further demonstrated in the actual innovative solutions that were available for assessment. It was observed by the study that twenty-five (25) out of forty-two (42) innovative solutions had significant originality in them. This included solutions farm inputs and machinery, home appliances, home furniture, energy saving equipment among others. Five (5) of the items were found to be incremental in their technology thus they had their strength founded on already existing technology solutions, particularly household furniture and farm equipment. Nine were transformative in that they were deviating from the normal ways and practices, such as use of different sources of energy, adopting alternative techniques in farming among others. They provided alternative ways of accomplishing day-to-day demands. The mind-set of innovators was found to be right for commercial innovations. This reiterated what was established by Ndemo and Aiko (2016) that there was a positive attitude amongst African innovators in regard to their ability to be creative.

4.6.7 Enthusiasm in commercialising innovation

When innovators were asked whether they were enthusiastic about commercialising their innovations, most of them agreed that they were enthusiastic. An innovator who comes up with an innovation is always eager to know how the product will be received in the market. This motivates the innovators to create products that are appealing and obtain feedback from the users. It can be seen in table 4.9 that 12.4% (12) disagreed, 14.4% (14) were not sure and 73.2% (71) agreed that most innovators in their institutions were enthusiastic about commercialising their innovations. This is further supported by a study on paradigm shift in disruption, creativity and innovation in Kenya. It indicated that young start-up entrepreneurs were transforming the technosphere in areas such as information technology solutions and telecommunication, as witnessed by increased global recognition and spinoffs (Ndemo, 2016).

4.6.8 Self-motivated innovators

Self-motivation is critical characteristic of an innovator. It serves to provide a self-drive to achievement of an objective, in this case a product or idea. Most innovators are persuaded by their inner desire to develop their products and even to commercialise them. It can be seen in table 4.9 that 6.1% (6) disagreed, 4.0% (4) were not sure and 89.9% (89) agreed that most innovators in TVET institutions were self-motivated. The study found that most innovators were self-motivated. Given that a higher degree of self-motivation is regarded to play a significant role in collaboration, it can be seen that innovators in TVET institutions had a higher potential of being good collaborators with external partners.

4.7 Correlation of research variables in innovations

Data collected on variables in this study was correlated by inferential statistics in order to establish relationship amongst variables. These tests were non-parametric measures since the study involved both continuous and rank-ordered variables.

Data collected by questionnaires in this study was not continuous but rather ordinal in form. Therefore, Spearman rho coefficient was used because it works with rank-ordered scores of a variable. This test is appropriate in cases where data is not normally distributed or has ordered categories, choose Kendall's tau-b or Spearman, which measure the association between rank orders (SPSS Inc, 2017).

Furthermore, before data could be adapted for use in these analyses, preliminary examination of data was carried out. It involved checking for outliers and assumption of normality (IBM, 2021).

4.7.1 Preliminary tests - Skewness and Kurtosis tests of normality

The skewness and Kurtosis tests were run on the data before carrying out correlation.

Table 4.10: Descriptive on Skewness and Kurtosis

Variable of the study	Statistic	Std. Error	Significance
i. Use of external knowledge to strengthen own innovations	Skewness	-.389	.243
	Kurtosis	-.438	.481
ii. Value creation for internally developed innovations	Skewness	4.386	.243
	Kurtosis	25.725	.481
iii. Collaboration with external partners	Skewness	3.602	.243
	Kurtosis	24.037	.481

The skewness values of statistics were divided with the standard error to obtain the significance value. A value between -1.96 and +1.96 indicated a normal distribution. It

can be seen in table 4.10 that data on use of external knowledge to strengthen own innovations had statistically significance of being drawn from a normally distributed population. However, the data on the other two objectives on value creation for internally developed innovations and collaboration with external partners has statistical evidence of not being drawn from a normally distributed population.

4.7.2 Pretest - Shapiro-Wilk test of normality

The study carried further tests on normality as recommended. The sample size in this study was ninety-nine, which is in-line with the definition of a small sample in common practice in data analysis (Ezie, 2021). Shapiro-Wilk test of normality is suitable in analysis of small samples that are less than 100 samples (Statistics How To, 2023). It was used to check whether the data was drawn from a normally distributed population. Variables giving a p-value of more than 0.05 are regarded to be from a normally distributed population (Grande, 2016).

Table 4.11: Shapiro-Wilk test of Normality

Variables	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
i. Use of external knowledge to strengthen own innovations	.094	99	.030	.973	99	.038
ii. Value creation for internally developed innovations	.246	99	.000	.575	99	.000
iii. Collaboration with external partners	.167	99	.000	.740	99	.000

a. Lilliefors Significance Correction

Table 4.11 shows the Shapiro-Wilk values of transformed data. The three variables that signify TVET institutional practices had p-values of .038, 0.000 and 0.000. It is worth noting that all these values are less than 0.05 which imply a less likelihood that data meets that assumption of normality. Further, it can be seen in Appendix XII, of

untransformed data, that Shapiro-Wilk test revealed that the data was statistically different from that of a normal distribution. The scores obtained had p-values of 0.00 which are less than the statistical significance level of 0.05 thus the data violates the assumption of normality.

4.7.3 Correlation of variables of TVET practices

The Spearman Rho Correlation was executed on the data to establish the degree of correlation between the variables under study (SPSS Inc, 2017). It can be seen in table 4.12 that there is a moderate positive correlation between the three variables of institutional practices in commercialisation of TVET innovations. The table shows that use of external knowledge to strengthen own innovations positively correlated with value creation for internally developed innovation yielding a correlation co-efficient of 0.451 which is a moderate correlation and is statistically significant.

Table 4.12: Correlation of variables

		Use of external knowledge to strengthen own innovations	Value creation for internally developed innovations	Collaboration with external partners
Use of external knowledge to strengthen own innovations	Correlation Coefficient	1.000	.451**	.645**
	Sig. (2-tailed)	.	.000	.000
	N	99	99	99
Value creation for internally developed innovations	Correlation Coefficient	.451**	1.000	.616**
	Sig. (2-tailed)	.000	.	.000
	N	99	99	99
Collaboration with external partners	Correlation Coefficient	.645**	.616**	1.000
	Sig. (2-tailed)	.000	.000	.
	N	99	99	99

Regarding use of external knowledge to strengthen own innovation versus collaboration with external partners, a positive correlation coefficient of 0.645 was established and was statistically significant. This indicates a slightly stronger positive correlation between these two variables (Leerkes & Howell, 2018). It was further established that a positive correlation coefficient of 0.616 existed between value creation for internally developed innovations and collaboration with external partners. This indicates a slightly stronger correlation between the two variables.

4.8 Modelling of commercialisation of innovative solutions based on institutional practices of TVET institutions

Based on the data obtained in this study, a model of commercialisation of TVET institutions' innovative technology solutions was developed. The development involved analysing factors necessary for successful commercialisation of TVET innovative technology solutions in TVET institutions based on TVET institutional practices. Exploratory Factor Analysis (EFA) was carried out to determine those factors (Dell Software, 2015a).

Although not all underlying relationships were discerned, prominent ones were identified in order to assist in explaining most of the variance observed in the manifested variables (Research Coach, 2018). Moreover, Varimax method, an orthogonal rotation method, was used to minimize the number of variables that have high loadings on each factor (SPSS Inc, 2017). This method was employed to simplify initial factor loading estimates as well as interpretation of the underlying influence. This uncovering of patterns gave rise to the development of a model that related and explained the latent variables underlying the already discussed correlation.

As suggested by Tabachnick & fidell (2013), the correlation matrix in this study was examined for correlations in excess of 0.30. If the matrix had none then there would be no need to factor analyse the data. It was found that all attributes involved had at least correlated with several others at coefficients that exceeded the 0.30 threshold. The matrix also indicated that there were more factors that still exert some influence to the unobserved pattern of underlying variables. This was observed in the correlation between other attributes that comprised indices values above and below the threshold in other cases.

To improve this situation, attributes that showed very weak correlation were eliminated as suggested by Field (2018), leaving 23 attributes to be factor analysed. It was also noted that the determinant of the matrix was 4.486×10^{-5} , thus greater than the suggested Field's threshold of 1.0×10^{-5} (Field, 2018). This indicated that multi-collinearity was not a problem in this analysis.

The study therefore had a reason to move ahead with other preliminary tests which were conducted to check further factorability of the data. These tests included Bartlett's test and Kaiser-Meyer-Olkin Measure of Sampling Adequacy (KMO MSA) that checked whether it was reasonable to carrying out EFA on the collected data. Table 4.13 illustrates the results of the Bartlett's test which were thereafter discussed.

The KMO MSA concerns with testing whether partial correlations among variables are small (SPSS Inc, 2017). Bartlett's test of sphericity assessed the appropriateness of factor analysis. Factor analysis would not have been appropriate had the correlation matrix been an identity matrix. As indicated in the test scores, KMO MSA was found to be 0.613 hence above the 0.5 minimum threshold.

Table 4.13: KMO and Bartlett's Tests

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.613
Bartlett's Test of Sphericity	Approx. Chi-Square	1154.631
	Df	253
	Sig.	.000

Furthermore, Bartlett's test of sphericity was 0.000 hence was statistically significant. This inferred that the correlation matrix was significantly different from an identity matrix (Crowson, 2019). Therefore, the matrix not being an identity one meant that EFA could be carried out without violating the assumptions. Running EFA (see Appendix XIII) and rotating the resulting factor matrix, using the Varimax method of rotation at eigen-value 1.00, led to the extraction of seven underlying constructs with significance influence to commercialisation. Table 4.14 presents the rotated factor matrix the interpretation of the seven underlying variables.

4.8.1 Underlying variable one

The rotated factor matrix indicated that the first most significant underlying pattern, thus observed in underlying variable one, was dominated by attributes listed in table 4.15. It was observed from the table that these attributes revolved about collaborative relation which TVET institutions cultivated and explored with external partners. These included partnerships with industries with regard to innovating for commercial reasons, attracting intellectual resources and funds, actively searching for worthwhile partners including engagements that added value to TVET institutions' innovation.

In other words, these underlying variable had to do with practices that support formation of strong partnership. Therefore, this most dominant factor, statistically was inclined more towards having a corporation with other worthwhile partners outside the realms of TVET institutions.

Table 4.14: Rotated Factor Matrix – Exposing seven underlying variables

Prominent attributes of the rotated factor matrix	Underlying Variables (Factors)						
	1	2	3	4	5	6	7
1. The institution evaluates and acquires intellectual property rights for use in internal innovations	-.092	-.020	.103	.117	-.110	.677	-.011
2. The institution has infrastructure e.g. workshops for exploring ideas and obtaining feedback	.333	.182	.354	.029	.276	.235	-.236
3. The institution has a committee for commercialisation of innovations	.049	.205	.345	.415	.063	.054	.128
4. The institution has a business strategy for most innovative products	.135	.288	.212	.082	.132	.195	.121
5. My innovative products have aesthetic looks to make them more viable for commercialisation	.207	.270	-.156	.047	.323	.489	.390
6. There is viability of products against cost of production	.319	.271	-.259	-.125	.152	.701	.095
7. Innovators in this institution are rewarded for coming up with commercially	.485	.362	-.003	.361	.051	.084	-.189
8. The institution has a practice that innovation must have quality production for profit	.155	.798	.143	.036	-.242	.096	.002
9. The institution has a practice that innovation must be demand driven	.168	.760	.147	-.061	.359	.047	-.085
10. The institution holds frequent meetings to discuss innovation and their commercialisation.	.149	.103	.466	.400	.027	.210	-.172
11. Is internal value addition affected by insufficient funding?	.150	.117	.098	.094	-.001	.022	.663

12.	Institution has acquired rights to use intellectual property from external innovators	.059	-.001	.784	.119	-.007	-	.087
13.	The institution has sold some of Intellectual Property Rights to external innovators	.270	.229	.702	.040	.135	-	.076
14.	The institution incorporates external research to add value to our innovations	.522	.498	.011	.352	.209	.109	.132
15.	This institution utilises internal research and development to add significant value to our innovations	.302	-.059	.116	.783	.121	.107	.268
16.	Institution's technical facilities have a positive influence in my effort/ability to commercial my innovation	.187	-.056	.147	.487	.383	-	-.240
17.	The institution actively searches for collaboration	.748	.338	-.056	.224	.073	.049	.006
18.	Our collaborators come by themselves to seek for our partnership	.661	.037	.248	-.072	.519	.073	.016
19.	In accepting collaboration, the institution considers: resource base. Intellectual resources and funding ability of collaborator	.804	.026	.083	-.018	.012	.181	.253
20.	The institution has adequate partnership with industries with regard to innovating for commercial purpose..	.828	.019	.316	.183	-.179	-	-.050
21.	Collaborators have brought critical resources to the institution	.778	.288	.263	.253	-.061	-	-.054
22.	Most innovators in this institution are creative	.098	.134	-.014	.004	.195	-	-.560
23.	Most innovators in this institution are self-motivated to innovate	-.140	.071	.070	.259	.823	.017	-.191

Extraction Method: Principal Axis Factoring.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 11 iterations.

Table 4.15: Observed attributes that influence underlying variable one

Observed attributes	Significance (Eigen-value)
1. The institution has adequate partnership with industries with regard to innovating for commercial purpose.	0.828
2. In accepting collaboration, we consider the following: resource base, intellectual resources of the collaborator, funding ability e.t.c.	0.804
3. Collaborators bring resources in to this organisation	0.778
4. The institution actively searches for collaboration	0.748
5. Our collaborators come by themselves to seek for our partnership	0.661
6. The institution incorporates external research to add value to our innovations	0.522

4.8.2 Underlying variable two

It was seen from the extraction of the second most significant underlying variable, see table 4.16, that attributes 1 and 2 were more pronounced than the rest. These attributes related to practices that demanded innovation to have quality for profit and must be demand driven as well.

Table 4.16: Observed attributes that influence underlying variable two

Observed attributes	Significance (Eigen-value)
1. The institution has a practice that innovation must have quality production for profit	0.798
2. The institution has a practice that innovation must be demand driven	0.760
3. The institution incorporates external research to add value to our innovations	0.498
4. Innovators in this institution are rewarded for coming up with commercially viable innovations.	0.362
5. The institution actively searches for collaboration	0.338
6. Collaborators bring resources in to this organisation	0.288
7. The institution has a business strategy for most innovative products	0.288
8. The cost of innovations make them viable for commercialisation	0.271
9. My innovative products have aesthetic looks to make them more viable for commercialisation	0.270

This indicated that appropriate practices or policies on the quality of innovations and market need satisfaction are important elements in commercialising an innovation in a technology field. Other attributes that statistically had an influence, though not as much as the first two, were incorporation of external research to add value to the innovation as well as an aspect of rewarding or appreciating the innovator for the commercially viable innovation.

While the first two prominent attributes in this underlying variable inclined towards an innovation that is supported by practices to satisfy the market desires, the next two were geared to improving the quality of innovation through motivating the innovator and appealing to innovator's efforts to be more productive in individual performance. The attributes addressed the quality of input arising from innovator motivation and quality of output expressed in the final product. The contribution of other attributes can be seen to be dismal.

4.8.3 Underlying variable three

It was observed that the third underlying variable that was extracted had two dominant attributes as compared to other attributes, as seen in table 4.17. These attributes included one which sought to determine whether the institution had acquired intellectual properties from other innovators for use within its own innovative process and also whether the institution has sold out some of its own intellectual property rights to external innovators.

Other attributes that contributed statistically to this underlying variable included the institution holding frequent meetings and workshops for purposes of discussing commercialisation and exploring ideas to obtain feedback on innovations respectively. Other attributes that contributed to the underlying variable included partnership with

industry for commercialisation and availability of an innovation committee in the institution.

Table 4.17: Observed attributes that influence underlying variable three

Observed attributes	Significance (Eigen-value)
1. The institution has bought a few intellectual properties from other innovators to use in our institution	0.784
2. some of our intellectual property rights have been sold to innovators outside our institutions	0.702
3. The institution holds frequent meetings to discuss innovation and their commercialisation.	0.466
4. The institution has workshops for exploring ideas and obtaining feedback	0.354
5. The institution has an commercialisation of innovation committee	0.345
6. This institution has adequate partnership with industries with regard to innovating for commercial purposes.	0.316
7. Collaborators bring resources in to this organisation	0.263
8. Our collaborators come by themselves to seek for our partnership	0.248

It was observed that these extracted attributes suggested that this underlying variable had an incline towards institutional practices such as acquisition and sale of technologies. These practices aim to support innovation, strengthen improvement and management of innovation commercialisation processes. Sharing innovative knowledge both externally and internal is in tandem with the concept of open model (Chesbrough, 2003a), which advocates for a porous boundary between the innovating institution its ecosystem with regard to sale and acquisition of both IPR and products.

4.8.4 Underlying variable four

It was observed that the extracted fourth underlying variable had one prominent attribute. Table 4.18 shows that this prominent attributes that contributed significantly to this underlying variable was the institution utilisation of internal research and

development to add significant value to its innovations. Other attributes had not as much statistical significance on this underlying variable. These included one on TVET institutions' technical facilities having a positive influence in innovators effort or ability to commercialise their innovations. Other attributes that contributed to this underlying variable are shown in table below.

Table 4.18: Observed attributes that influence underlying variable four

	Observed attributes	Significance (Eigen-value)
1.	This institution utilises internal research and development to add significant value to our innovations	0.783
2.	Our institution's technical facilities have a positive influence in my effort/ability to commercialise my innovation.	0.487
3.	The institution has an commercialisation of innovation committee	0.415
4.	The institution holds frequent meetings to discuss innovation and their commercialisation.	0.400
5.	Innovators in this institution are rewarded for coming up with commercially	0.361
6.	The institution incorporates external research to add value to our innovations	0.352
7.	Most innovators in this institution are self-motivated to innovate	0.259
8.	Collaborators bring resources in to this organisation	0.253

An analysis on most attributes in this underlying variable suggested that this underlying variable depicts a practice in TVET institutions to utilise its resources effectively. It depicts the necessity the institutions to enhance the productivity of its innovators through influencing their attitude towards innovations and commercialisation of their technology solutions. This was seen in terms that dealt with motivation, rewards and frequent meetings to discuss innovation and commercialisation. This underlying variable promotes innovator's self-efficacy and the drive to achieve the best through self-determination.

4.8.5 Underlying variable five

It can be seen in the table below, that the fifth underlying variable that was extracted had attributes that related to self-motivated innovator, attraction of collaborative engagement, institution's facilities supporting innovators' efforts to commercialise innovations and demand driven innovative practice among others. This underlying variable was found to be similar to the fourth underlying variable that depicts productivity and utilisation of available resources. Table 4.19 indicates other attributes which contributed significantly to this underlying variable.

Table 4.19: Observed attributes that influence underlying variable five

	Observed attributes	Significance (Eigen-value)
1.	Most innovators in this institution are self-motivated to innovate	0.823
2.	Our collaborators come by themselves to seek for our partnership	0.519
3.	Our institution's technical facilities have a positive influence in my effort/ability to commercialise my innovation.	0.383
4.	The institution has a practice that innovation must be demand driven	0.359
5.	My innovative products have aesthetic looks to make them more viable for commercialisation	0.323
6.	The institution has workshops for exploring ideas and obtaining feedback	0.276
7.	The institution incorporates external research to add value to our innovations	0.209

A consideration of most attributes in this underlying variable suggested that it was closely related to that observed in underlying variable four. Attributes that promote innovator's productivity through provision an enabling innovative ecosystem were prominent in this underlying variable. This was observed by attributes such as self-motivated innovators who are positively influenced to commercial their innovations, institutional policies that promote demand driven innovations through exploration of

ideas and getting feedback to matters that incorporate external collaboration through partnerships and external research that added value to innovations.

4.8.6 Underlying variable six

It can be seen in table 4.20 that the sixth underlying variable had the following attributes:

Table 4.20: Observed attributes that influence underlying variable six

	Observed attributes	Significance (Eigen-value)
1.	The cost of innovations make them viable for commercialisation	0.701
2.	The institution evaluates and acquires intellectual property rights for use in internal innovations	0.677
3.	My innovative products have aesthetic looks to make them more viable for commercialisation	0.489
4.	The institution has workshops for exploring ideas and obtaining feedback	0.235
5.	The institution holds frequent meetings to discuss innovation and their commercialisation.	0.210
6.	The institution has a business strategy for most innovative products	0.195
7.	In accepting collaboration, we consider the following: resource base, intellectual resources of the collaborator, funding ability etc	0.181

The items that loaded this underlying variable were realised to have inclined towards efforts that focused on creation and enhancement of a competitive market edge by embracing an effective innovative and commercialisation process. This was observed in attributes that related to costs, aesthetics and feedback which had a higher loading in this underlying variable.

4.8.7 Underlying variable seven

It was seen that the seventh underlying variable had attributes with slightly lower loading factor. This comprised attributes such as internal value addition being affected by insufficient funding and innovative products having aesthetic looks to make them

more viable for commercialisation. It also contained utilisations of internal research and development to add significant value to innovations, collaboration based on resources and value addition to internal innovations based on input from external partners' research. This is shown in table 4.21.

Table 4.21: Observed attributes that influence underlying variable seven

Observed attributes	Significance (Eigen-value)
1. Is internal value addition affected by insufficient funding?	0.663
2. My innovative products have aesthetic looks to make them more viable for commercialisation	0.39
3. This institution utilises internal research and development to add significant value to our innovations	0.268
4. In accepting collaboration, we consider the following: resource base, intellectual resources of the collaborator, funding ability e.t.c.	0.253
5. The institution incorporates external research to add value to our innovations	0.132
6. The institution has an commercialisation of innovation committee	0.128
7. The institution has a business strategy for most innovative products	0.121

Underlying variable seven is geared towards value-addition to the innovative products and market strategies. This could be inferred from attributes that had to do with internal value-addition, product aesthetics, utilisation of internal research to add significant value, incorporation of external research to cause value addition and the presence of committee and business strategies related to commercialisation of the innovation.

4.9 Model of commercialisation of innovative technology solutions in TVET institutions

The underlying variables enabled the study to develop a model of commercialisation of innovative technology solutions for TVET institutions based on institutional best practices. The underlying variables revealed underlying practices that influenced the

relationship between variables. A model, shown in figure 4.1 was developed to encompass these practices, which strive to innovate with a business inclination. The practices aim to:

- i) support collaboration, hence formation of strong worthwhile partnerships.
- ii) Promote necessary internal policies on innovation commercialisation.
- iii) Promote efficient and effective internal processes and enablers of innovation commercialisation.
- iv) Embrace sufficient utilisation of resources
- v) Improve productivity of innovators in embracing innovations for commercial purpose.
- vi) Seek to establish market competitiveness by exploiting a market niche, feedback and employing business strategies.

In this model, the study viewed the factors that contribute to a successful innovation commercialisation as interconnected ecosystem comprising functional dimensions that inform and cause transactions amongst each other. Rather than being linear, where transactions are sequential, in this model each dimension influences the processes that occur in any other dimensions within the ecosystem. The channels of communications and committees such as the innovation committees, or commercialisation committee or research and development interlinks the all the concerned dimensions.

The innovation commercialisation process may begin with conception of an innovative idea or by acquisition of a spin-in products from external partners. The ideas and spin-ins can be informed or reformed by feedback from any of the dimensions in the model. For instance, internal policies will determine how collaboration will be carried out while the nature of collaboration influences the formulation of internal policies.

As pertains the internal policies dimension, TVET institutions can prosper better by formulating beneficial policies that ensure institutions have resilient business strategies, promote quality of already existing innovations, ensure upcoming innovations are high quality oriented, market driven innovations, embrace rewarding of innovators and facilitate resource mobilisation.

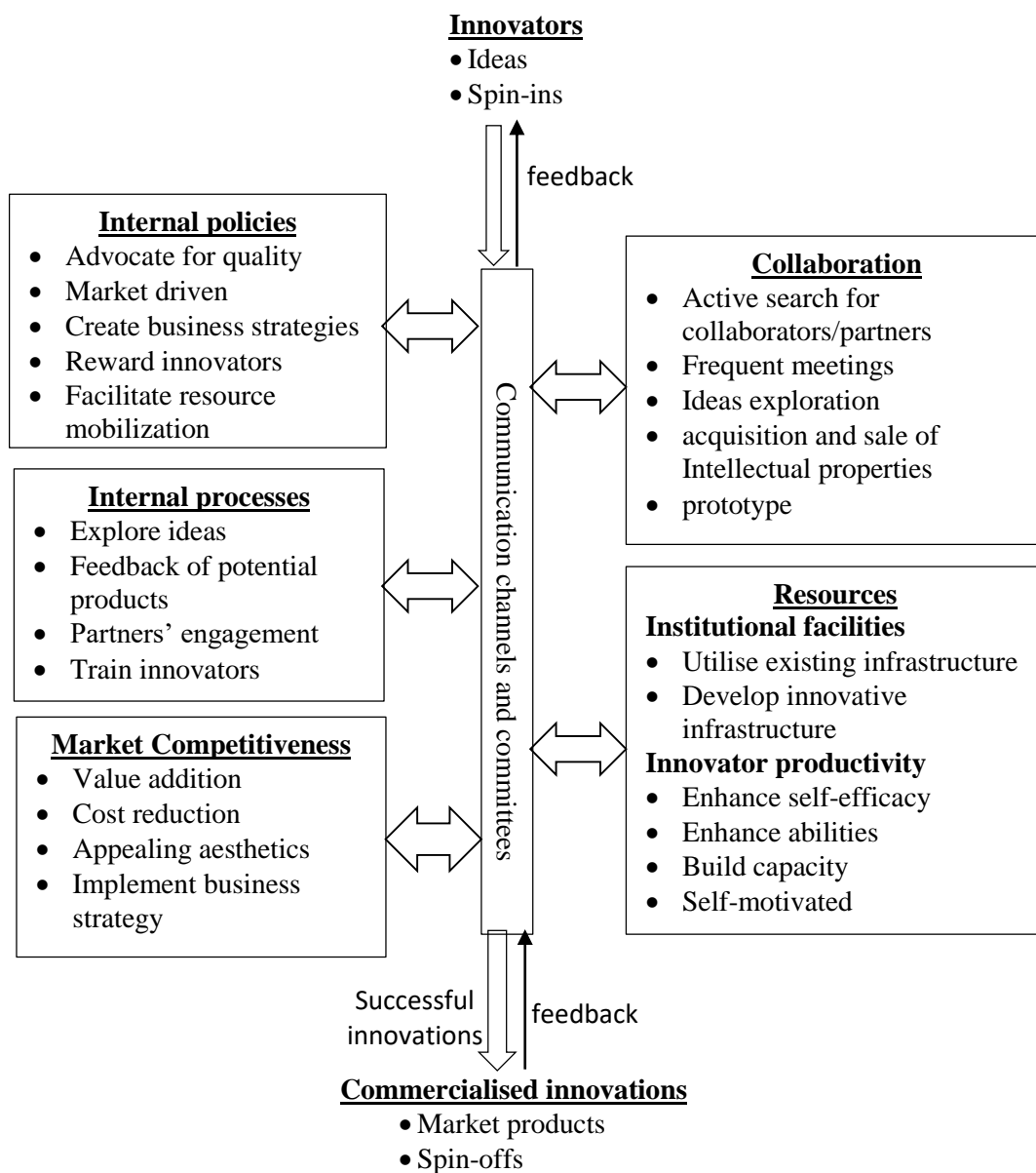


Figure 4. 1: A Model of Commercialisation of technology innovations for TVET institutions in Kenya

(Source: Author, 2020)

This model emphasises the need for TVET institutions to actively seek out collaboration that bring on board worthwhile partnerships. Worthwhile partners in the sense of having the will and capacity to either fund, prototype, add-value or mass manufacture innovations for purposes of commercialisation. The institutions and partners need frequent meeting to explore ideas as well as deliberate on issues of interest to the innovations that would lead to marketing it. This also builds trust and understanding as each party gets to understand the expectations of the other. Since partnerships bring different strengths to the organisation, they can be useful in acquiring IPR for external technology that could be used to further improve the innovation.

Then there is the dimension of internal processes. This dimension focuses on exploration of ideas and acquired spin-ins to improve the products. Tests and prototyping which give feedback on the characteristics of the innovation. There is partnership engagement in internal processes by sharing and assisting the TVET with advice from visiting expertise. Innovators also undergo training in skills needed to produce the product. This are technical skills that would allow innovators to infuse various available technologies in-order to reduce the incubation period of an innovation. This involves techniques such as simulations, 3D printing, prototyping and others.

The resource dimension advocates for effective and efficient utilisation of facilities that are in the institutions. These include use of workshops, fabrication labs, innovation labs among others. It also advocates for acquisition of necessary resources that are necessary for innovations commercialisation. The TVET institutions can enhance the productivity of innovators. The path to innovations is not simple. It takes innovators' self-motivation, self-efficacy, self-determination and requires an innovator to possess multifaceted skills. TVET institutions need to ignite these traits or build an ecosystem that leads to the development of the traits.

The dimension of market competitive is probably one that determines the ultimate success or doom for the innovated product in the market. TVET institutions have to strive to explore the market niche by having innovations that appealing aesthetics in addition to adding value above competitors' products. The cost of production has to be low to allow for profits margins. By also rolling out their market strategy which include obtaining feedback on the performance of their commercialised product. This feedback comes back to improve each dimension in the model. These enable the products to meet market desires. Successes can also be realised by selling off innovations in form of spinoffs to other external players.

4.10 Chapter summary

The results from data analysis have been presented. They indicated a satisfactory response rate that enables the results to be a true representative of the population under study. Innovators background has been analysed. In addition, the resulting analysis of the four objectives of the study have been presented and interpreted in-line in a themes of the study. Data was transformed by EFA methods. This led to determination of underlying variables, their presentation and thereafter development of a model of commercialisation of technology solutions of TVET institutions. The model is presented and it identified seven most influential variables to the process of commercialisation of innovations.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Chapter overview

This chapter dwells on the summary of findings and draws conclusion based on the findings. It then gives recommendations which are aimed to benefit TVET institutions and other stakeholders in the process of commercialising their innovations. The chapter also suggests further areas of research that could be conducted to broaden knowledge in areas related to this study.

5.2 Summary of findings

The response rate of participants in this study met the requirements for minimum sample as dictated in the sampling techniques and sampling procedure. This meant that data collected had a significant probability of representing the population under study. Hence, could be analysed and generalised to the population.

5.2.1 Background information of the respondents

Background information of the respondents demonstrated that most innovators in TVET institutions had little experience in terms of years they have been involved in the field of technology innovations. This was observed from the low number of years they possessed in participation in innovations. Furthermore, it was observed that the number or quantity of technology innovative solutions created by these innovators was low. Consequently, the quantity of innovations which managed to be commercialised was much lesser. It was noted that most innovators were still in their early years in innovation and hence had not acquired as much years in innovations. This implied that the

innovators may still be learning the best practices in innovations and commercialisation of their products.

Since innovation with a commercial angle requires substantial experience which can only be accumulated over time, the innovators in TVET institutions could be possessing the will but lacking in experience. This in turn impacts negative to the mastery of finer competences that may be crucial to innovating a commercially viable technology product. The higher the experience level, the more likelihood for a positive influence to the outcome of the innovation process and commercialization of the resulting products.

Most innovators possessed a bachelor's degree in their specialisation. Even so the innovators exhibited varied levels of academic qualification ranging from certificate to doctorate. This is a strength to innovation works because it provides a broad base for sharing knowledge and skills derived from such varied backgrounds of training.

It was noted that majority of innovators had not undergone any training deliberately aimed to sharpen their innovative skills. Similarly, very few had training in skills related to commercialisation of innovations. With no such training, TVET institutions' efforts to commercialise their innovations is greatly hampered. As indicated the situation at TVET institution is such that innovators possessed little or no training in competencies regarding innovation commercialisation practices. Consequently, innovative technology products have challenges in meeting market standards and levels that could make them attractive and viable in the market. If innovators had some training in innovation commercialisation, they would utilise these skills from the on-set of their activities thereby influencing their every step of the way. This would ensure by the end of the processes the outcomes are suitable for commercial purposes.

5.2.2 Use of external technology in strengthening own innovation

Most of TVET institutions have institutionalised a policy on IPR and have guidelines on how to acquire intellectual property rights, mostly for their innovations. Innovators acknowledged that their institutions strived to evaluate and acquire IPR. However, it was noted that there exist insufficient internal guidelines on how to evaluate and acquire external IPR for use in internal processes. Government agencies on their part have contributed to sensitising TVET institutions on matters concerning IPR. TVET institutions have agreements and MoUs with partners. These arrangements provide mechanisms for them to get access to external technologies and even knowledge which could be used for innovations.

Similarly, knowledge of the market segment and desires cannot be understated. TVET institutions are well aware of the advantage posed when such knowledge is sought. However, there is little evidence to suggest that these institutions go an extra mile to seek such knowledge about niche markets through activities such as market survey. It was also observed that although committees on income generation or research exist in TVET institutions, majority of innovators were not aware that such committees are charged with the mandate to commercialise their innovations. This may imply that committees may not be sensitising innovators on their roles. In addition, they seem not to be cognisant of the fact that technology innovations are different from normal business ventures and need to be given much attention to be commercialised. As a result, real commercialization of ST&I products was yet to be realized. Furthermore, it emerged that innovations that reach such committees are not treated with the unique intricacies that merit technology innovations rather they are subjected to ordinary processes like non-technical undertaking for generating income.

This creates a breakdown in chain that links innovation to commercialisation. This breakdown was also witnessed when innovators were asked to state whether their institutions had a business strategy for their innovation products. It was realised that most innovators believed no business strategy existed yet in the opinion of the heads of sections there existed a strategy. Innovators also acknowledged that they strive to incorporate aesthetic looks to their innovative solutions. This was done with the aim to have an appealing product to the end user. In addition, they try to produce innovations at low costs. However, a third of innovators noted that they still do not actively factor the cost of production into their work.

The study identified that TVET institutions encounter challenges in establishing partnerships with external players, as noted by the heads of institutions and government agencies. Drafting and securing MoUs was a significant challenge. This challenge is due to scepticism and lack of good will to support TVET institutions. To some industry players, it just does occur to them that the institutions in TVET can worthwhile partners. More so, the situation is worsened by unclear and conflicting government policies or guidelines on how to go about with partnership formation.

Evidence in documents surveyed revealed that little market need analysis was conducted to determine market niches and needs. In contrast, most innovators observed that they considered market needs when coming up with innovative technology solutions. Further, the study established that most innovators were not sure whether their institutions provided rewards to innovators who had successfully created technology solutions that were commercially viable. This may be attributed to either lack of proper dissemination of organisation's policies, non-clear guidelines or practices on rewards. Promising innovators need to be rewarded for their work as studies have revealed a

significant direct correlation between reward and employee engagement in field of innovation. A reward system would prevent negative practices such as innovating for the sake of it.

The innovators agreed that their institutions underscore the need for quality innovations that are inclined for profit. However, an analysis of document did not reveal any supporting evidence. Similarly, innovations presented to the research indicated that only a third of them could withstand market standards. The rest of the innovative technology solutions had not been polished to meet market standards. This could hamper efforts to commercialise these products or to seek funding for further development of these innovations.

On the existence of a practice that promotes demand driven innovations, it was found that institutions and most innovators believed there exists such a practice. Therefore, this suggested that innovators understood the importance of focusing their efforts to solutions that would meet clients' demands. This was supported with observations on innovative projects seen by the research which had incorporated unique functionalities and innovative ideas that were tailored to satisfy market demands. Innovators had the ability to convert their unique ideas to reality. It was also established that TVET institutions held meetings to discuss matters to do with innovations and commercialisation, but such meetings were not as frequent as to elicit appreciation and ignite the desire in innovators to commercialise their innovations.

5.2.3 Value addition for internally developed innovations

Value addition to internally developed innovations is a critical process that enhances the quality and functionalities of an innovation. Despite this fact, innovators stated that

insufficient funds hindered this process to a great extent. This hampered their ability to modify or upscale as well as affecting improvement on their innovative products. It was also noted by majority of innovators that their institutions have not purchased or acquired intellectual property rights from external partners to facilitate internal value creation. On the other hand, it emerged that institutions had not sold any rights to external partners. This failure to utilise both internal and external technologies affects the ability of TVET institutions to promote internal value addition as well as enhance productivity while reducing the incubation period for innovations.

This practice is not health for institutions in that TVET institutions fail to get revenue for intellectual property that may be lying unutilised within the organisation. It was realised that institutions do not feel the need to acquire such rights since it is assumed that in collaboration agreements they would still have access to such rights anyway. However, it may not be obvious to assume that this might always be the case, since individual members of parties may exhibit distrust amongst themselves.

It was established that innovators utilise internal facilities to carry out innovative activities and hence the degree of viability to commercialise significantly depended on these facilities. Thus most innovators were highly reliant on institutional facilities for their activities. Lack of innovation infrastructure hampered the ability to develop competitive products for commercialisation thereby impeding improvement of quality of already existing technology innovations.

Despite of the challenges, innovators still acknowledged that they incorporated external research in value addition. It is a good practice as it cuts the incubation time for ideas and products hence enabling a much faster process. Likewise, they conducted internal research and development to create value to their innovations. Innovators also stated

that they protected the results of their activities through patent acquisition, although this was challenged by sentiments of government agencies. All in all, it was certain that TVET institutions experienced great challenges in development of conceived ideas, aesthetics and quality of innovations as they are often not able to enhance, upscale or modify the functions for existing innovations.

5.2.4 Collaboration with external partners

TVET institutions stand to gain a lot by engaging in collaborative activities as they provide avenues for technology transfer and sharing. The study noted that majority of innovators indicated that the institutions actively sought for collaborators. Identification of collaborators to be persuaded on board, depended on the potential or ability of the collaborator in terms of resources such as equipment, expertise, funds among others. On the other hand, they were not sure whether collaborators sought the institutions. However, minority of innovators pointed out that some collaborators seek out the TVET institutions.

It was observed that participation in this collaborative activities was still low. TVET institutions and innovators were not adequately engaging partners in issues of innovations. Therefore, they were not reaping the fruits that come with these partnerships. As a result, not many innovators believe that collaboration has been beneficial so far.

It was encouraging that most innovators considered themselves as creative, which was demonstrated in most technology innovations that were at the institutions. In addition, it emerged the innovators were enthusiastic about innovation. They also acknowledged

that they were self-motivated. These are positive traits of a good innovator which serve to boost collaboration and increases the quality of their innovations.

5.2.5 Correlation of research variables

The study established that there was a positive correlation between use of external knowledge to strength own innovations and value creation for internally developed innovations. The moderate correlation supported by statistical evidence implied that TVET institutions are most likely to create innovations with more value added to them if they incorporated knowledge and technology derived from outside technologies and expertise to their own knowledge and technology. However, an important point to note from this and similar correlations is that correlation does not imply causation (Ramzai, 2020).

There was moderate positive correlation which indicated that TVET institutions by utilising external knowledge to strengthen own innovation may boost their collaborative engagements with external partners. Similarly, a slightly higher correlation established between value creation for internally developed innovations and collaboration with external partners. This statistical evidence indicated that when TVET institutions enhance collaboration with external partners in developing their innovations for commercialisation they are likely to have a higher value creation practices for their internally developed TVET technology innovative products.

5.2.6 Model of Commercialisation of innovations in TVET institutions

There was a moderate positive Spearman Rho correlation index of 0.451 between use of external knowledge to strengthen own innovations and value creation for internally developed innovation. A similar positive correlation of index 0.645 was realised

between use of external knowledge to strengthen own innovation and collaboration with external partners. Further, a positive correlation of index 0.616 between value creation for internally developed innovations and collaboration with external partners. Information obtained from correlation informed the development of a model that reflects what TVET institutions ought to embrace in order to be successful in innovation commercialisation.

The model identified that proper internal policies that embraces creation of business strategies, rewarding of innovators, facility resources mobilisation and advocacy for quality innovations which are market driven are important. It points out that TVET institutions need to search actively for worthwhile partners, have frequent meetings, prototyping and explore ideas with collaborators, as well as acquire and sale IPRs. Further, it emphasised the need for critical internal processes that promotes exploration of ideas, obtaining feedback on potential products, partners' engagement and training of innovators in both technical skills and commercial innovation skills. This is in-line with several models of commercialisation that were proposed for research institutes and even for research outputs in technology universities.

Moreover, effective utilisation of resources both facilities and internal expertise serves as a mode to enhance productivity of TVET institutions in innovations. Some attributes identified included utilisation of existing and acquisition of new infrastructure, enhancing innovator attitude like self-efficacy, capacity, motivation and abilities. Finally, the model underpinned the success of products in the market to implementation of a vibrant market strategy that embraces value addition practices, cost reduction of innovative activities and appealing aesthetics for products.

5.3 Conclusions

This study concluded that:

- i) The ability of TVET institutions to successfully undertake innovation commercialisation is greatly impeded by the capability of most of their innovators. Most innovators were yet to acquired sufficient skills and experience relevant to both innovation commercialisation and their field of specialisation.
- ii) Some institutional practices that would have supported development of quality innovations were yet to be fully embraced. Processes such as incorporation of formal robust mechanisms for evaluating and acquiring external IPR had been neglected. If practiced, it would boost institutions' abilities to use modest technology and knowledge while innovating.
- iii) TVET institutions were deprived of sufficient knowledge on market niches and demands since they were not conducting market surveys as a prior activity to undertaking most of their innovations. This failure hampered their ability to establish which direction their innovations should pursue.
- iv) TVET institutions were well aware of the need to commercialise their technology innovations. However, most innovators were not aware of existence of committees responsible for commercialisation of their innovations. More so, TVET institutions apparently seemed not to possess a robust business strategy for technology innovations. In cases where a strategy exists, it was evident that innovators were not aware of it.
- v) Innovators were not aware of a reward system for successfully innovating a commercially viable product. This lack of knowledge on a rewarding system or even total lack of reward affects the determination, motivation, general morale

of innovators and by extension compromises the dedication to produce a quality output.

- vi) Although the Kenyan government emphasises on the need to have innovations commercialised, its policies and guidelines still remain unclear on how TVET institutions should engage partners, especially in the manufacturing sector in matters regarding commercialisation. This hinders the formation of clear partnerships as each side does not understand the context, expectations and limits of the other.
- vii) TVET institutions' have limited ability to realise market competitive innovations through value creation for internal developed innovations. This has been caused by insufficient funding towards innovations, failure to purchase IPRs, failure to acquire patents and insufficient innovation facilities. This has resulted in limited testing, low aesthetics and inadequate improvements to innovations.
- viii) TVET institutions acknowledged the significant role and benefits of collaborations in innovation commercialisation. However, fruitful engagement between collaborators and TVET institutions was still low and therefore not much was realised in terms of utilising the existing collaborations for purposes of innovation commercialisation.
- ix) The use of external knowledge to strengthen own innovations, value creation for internally developed innovation and collaborative engagement with external partners had moderate positive correlations amongst themselves. The correlation indicated that proper internal policies, collaboration, internal processes, resources and establishing market competitiveness were critical in innovation commercialisation process.

5.4 Recommendations

This study recommends the following:

- i) That TVET institutions need to train, expose and retain innovators in the processes of innovation commercialisation. This would breed a crop of highly skilled and experienced innovators who are able to enrich their innovative technology solutions while still inclining towards commercialisation. This would make commercialisation of innovative solutions easier to realise.
- ii) TVET institutions should endeavour to create, embrace and maintain robust institutional mechanisms and processes that enhance their ability to create commercially viable innovations. This would make it easier convert innovations to market products.
- iii) TVET institutions should strive to develop an informative and robust market strategy for their commercially viable technology innovations. Such a strategy should focus on conducting market niche surveys, identification of suitable partnerships for production and attracting investment. Since private investors would like value for their money, market niche survey reports may assist in convincing investors.
- iv) Government, industry partners, international development partners and TVET institutions to deliberate and develop clear policies and guidelines on engagement of TVET institutions with partners in regard to pursuing commercialisation of innovative solutions. This should include structures for overall development of infrastructure and capacity building in innovation commercialisation as well as promote private sector investment in the area of commercialising innovations.

- v) TVET institutions should pursue value-addition on existing technology innovations. This can be done through testing and improving performance and range of functionalities of innovations. Effective utilisation of available infrastructure can also assist in improving the value of innovations.
- vi) TVET institutions to adopt a model that promotes seamless interaction of parties in innovation commercialisation. This will streamline formulation of internal policies, collaboration with partners, resource acquisition, resource utilisation, and establishment of market competitive practices that will eventually lead to commercial success of their technology innovations.

5.5 Suggestions for further research

In line with the findings of this study, the research identified important researchable areas that could be undertaken in future. These areas are outlined below.

- i) A case study of selected innovative TVET institutions based on the model of commercialisation of innovative technology solutions of TVET institutions. This could be conducted with an aim of testing the accuracy, practicability and success of the developed model. This should comprise selected TVET institutions and selected innovators with sufficient experience in innovative technology solutions and be trained in innovation commercialisation skills.
- ii) A comparative study could be carried out to test whether the model generates higher rates of innovation commercialisation when adhered to. This study could comprise two sets of TVET institutions. One set with trained innovators in innovation commercialisation skills and the other set to serve as a control group. This will establish whether there exists a statistical significance between the two groups in terms of commercialisation rate.

iii) A study to determine factors that hinder external partners from collaborating with TVET institutions in innovation commercialisation. Since TVET institutions are not sufficiently engaging with partners, as well as partners not responding satisfactorily in support to innovation commercialisation, it may be prudent to establish what challenges external partners encounter in their endeavour to engage with TVET institutions in matters of innovation commercialisation. Failure to understand their side of the coin, and consequently not addressing the concerns that may arise will continue to cause TVET institutions' efforts to commercialise innovations to be futile.

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APPENDICES

APPENDIX I: Research Licence

REPUBLIC OF KENYA
NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

RefNo: 419168

RESEARCH LICENSE




This is to Certify that Mr.. Cornelius John Kiberenge of University of Eldoret, has been licensed to conduct research in Bungoma, Kakamega, Kiambu, Kisumu, Meru, Mombasa, Nairobi, Nakuru, Nandi, Nyeri, Siaya, Transzoia, Uasin-Gishu on the topic: The Influence of Institutional Practice on Commercialisation of Innovative Technology Solutions: The Case of TVET Institutions in Kenya for the period ending : 15/November/2022.

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APPENDIX II: Letter of introduction

University of Eldoret
School of Education
Department of Technology Education
P.O. Box 1125 -30100
Eldoret, Kenya

Date:

To: _____

Dear Sir/Madam,

RE: FACILITATION FOR DOCTORIAL THESIS RESEARCH PROJECT

I am a student at The University of Eldoret in the Department of Technology Education. I am pursuing a doctorate in technology education. I am conducting a study on Commercialisation of Innovative Technology Solutions in TVET institutions in Kenya. I wish to request permission to carry out research in your institution(s). Your co-operation in providing necessary assistance, information and documents will be highly appreciated and will contribute to existing knowledge on the subject under study. Attached please find a licence granted by NACOSTI for conducting this study. Thank you in advance.

Yours sincerely,

Kiberenge Cornelius John
Researcher

APPENDIX III: Letter of transmittal

University of Eldoret
School of Education
Department of Technology Education
P.O. Box 1125 - 30100,
Eldoret, Kenya.

Date: _____

To: TO ALL RESPONDENTS

Dear Sir/Madam

RE: FACILITATION FOR DOCTORIAL THESIS RESEARCH PROJECT

This study is about institutional practices that impede commercialisation of innovative technology solutions, a case of selected innovative TVET institutions in Kenya. It seeks to evaluate TVET institutional practices with regard to commercializing their technology innovations. The study will examine structures for innovation, value addition and challenges faced by TVET institutions in commercialising their innovations.

The study wishes to assure all participants of confidentiality of their information and identities. Data and information resulting from this study will be used purely for academic purposes of this study. **None** of it will be used to the detriment of either the respondent or institution. Your co-operation in providing necessary assistance, information and documents will be highly appreciated and will contribute to existing knowledge on the subject under study.

Thank you.

Yours faithfully,

Kiberenge Cornelius John
Researcher

APPENDIX IV: Interview schedule for Lead Officers in State Agencies

1. Kindly highlight some policies that this agency/organisation has that aim to promote enterprise development of innovations in TVET institutions?
2. In which ways does this agency/organisation support TVET institutions in innovations and commercialisation of their technology innovations? (thus, to identify, support and protect innovative ideas and products).
3. Which are the committees or linkages that your agency/organisation uses to promote commercialisation of technology innovations in TVET institutions?
4. What opinion does this organisation have on the worthiness of the innovative products that are exhibited by TVET institutions with regard to their commercial viability? (Do they meet technical standards, consumer expectations e.t.c?)
5. What suggestions would your organisation give to TVET institutions to improve commercial viability of their innovations?
6. Are there any investors, industry or entrepreneurs who have expressed interest in TVET institutions' technology innovations? If any what attracts them?
7. What challenges do these investors face in their attempt to engage TVET institutions in enterprise development? (Lack of technical skills, inadequate equipment, lack of originality).

APPENDIX V: Interview schedule for Heads of Institutions and Heads of innovation in TVET institutions

1. In which ways does this TVET institution use external knowledge (special knowledge sort from outside the institution) to strengthen their own innovations?
2. In which ways does this institution use external technology (equipment, products or skills from outside, market information) to strengthen their own innovations?
3. In which ways does this institution try and create value from internally developed innovations that are not immediately applicable in their own business?
4. What does this institution consider in selecting its collaborators and partners? (Do they come by themselves, do you actively scout for them, are they referred to you by other parties such as county or national government?)
5. In which ways does the institution structure its collaboration with partners? (Formal or informal) or (contractual, sporadic, random, or regular form of collaboration or by frequent meetings).
6. To what extent or percentage would you say collaboration and partnership in this TVET institution is formal? Or informal?
7. What do you consider in accepting collaboration? (Resource base, intellectual resources of the collaborator, funding ability?)
8. Does this institution have someone in-charge of commercialising innovations?
9. What are some of the initiatives that this institution has taken to enhance commercialisation of its innovations in the area of technology?
10. To what extend has this commercialisation of technology innovations succeeded?

11. What challenges does this institution face in trying to commercialise its technology innovations?
12. How does the institution deal with the challenges related to commercialising its innovations?

APPENDIX VI: Questionnaire for innovators in TVET institutions

INSTRUCTIONS

- i. Please answer all questions.
- ii. For sections two, three and four, provide responses by ticking (✓) the appropriate checkbox and giving additional information in the narrative questions.

SECTION ONE: BACKGROUND INFORMATION

1.1. Kindly state the number of years you have been in technology innovations?

_____ years

1.2. Please state your highest level of education: _____

1.3. Kindly list any other qualification(s) or training relevant to technology innovations that you possess? Also state the duration of the training.

1.4. Have you had any training in commercialising innovations? _____ (Yes/No)

If yes, list the training, also state the duration of the training.

1.5. How many innovations have you come up with? _____

1.6. How many have been successful? _____

1.7. What has made them successful/unsuccessful, kindly give reasons? _____

SECTION TWO: USE OF EXTERNAL TECHNOLOGY IN STRENGTHENING OWN INNOVATION

Please provide answers by ticking (√) the appropriate box for each question.

	Strongly agree	Agree	Not sure	Disagree	Strongly Disagree
i) This institution evaluates and acquires intellectual property rights for use in internal innovations.					
ii) It is important to consider knowledge of the market segment when you are innovating?					
iii) The institution has a commercialising innovation committee in the institute					
iv) Your institution has a business strategy for most innovative products?					
v) The finish aesthetic look of your finished innovative product makes it viable for commercialisation.					
vi) The cost of production of your innovative product makes it viable for commercialisation.					
vii) There exist challenges in drafting agreement e.g. Memorandum of Understanding (MoU) with partners					
viii) Is the approach to innovation a market-need driven? Thus solves a real life problem?					
ix) Innovators in this institution are rewarded for coming up with commercially innovative projects.					
x) The institution has a practice that innovation must have quality production for profit.					
xi) The institution has a practice that innovation must be demand driven.					
xii) There are frequent meetings to discuss innovation and commercialising of innovation.					

Give reasons why innovations in TVET may fail to be commercialised?

SECTION THREE: VALUE CREATION FROM INTERNAL DEVELOPED INNOVATIONS

	Strongly agree	Agree	Not sure	Disagree	Strongly Disagree
i) Is internal value addition at institution affected by insufficient funding					
ii) Institution has acquired rights of using intellectual property from external innovators					
iii) The institution has sold some of Intellectual Property Rights to external innovators					
iv) The institution has infrastructure e.g. workshops for exploring ideas and obtaining feedback.					
v) The institution incorporates external research to add value to internal innovations					
vi) This institution utilises internal Research and Development to add significant value to our innovation.					
vii) Institution's technical facilities have a positive influence in my effort/ability to commercial my innovation.List a few ways in which your efforts are affected.					
viii) Innovators in this institution protect their ideas by obtaining a trademark, design right or patent.					

Which infrastructure would you like to have in order to innovate more at institutional level? _____

SECTION FOUR: COLLABORATION WITH OTHER ENTITIES

	Strongly agree	Agree	Not sure	Disagree	Strongly Disagree
i) The institution actively searches for collaborators					
ii) Collaborators come by themselves to seek for our partnership					

iii) In accepting collaboration, the institution considers: resource base. Intellectual resources and funding ability of collaborator					
iv) There is adequate partnership with industries with regard to innovating for commercial purpose.					
v) Collaborators have brought critical resources to the institution					
vi) Most innovators in this institution are creative.					
vii) Most innovators in this institution are enthusiastic about commercializing innovations					
viii) Most innovators in this institution are self-motivated.					

i) Please give examples of some institutions which you are collaborating with in technology innovation or its commercialisation? _____

ii) Name some areas of collaboration with your partner institutions, if any? E.g. Funding, researching, inventing, commercialising, design of final product etc

iii)

APPENDIX VII: Document analysis

Evidence of commercialisation of innovative technology solutions:

1. Minutes of meetings of innovators,
2. Application for patents
3. Market survey: analysis, reports e.t.c.
4. Strategic plans in innovation and/or commercialisation.
5. Memorandum of Understanding (MoU) with partners, industrial partners
6. Correspondence between partners.

APPENDIX VIII: Observation Guide for Innovative Products

This guide seeks to establish the technology level of the innovative technologies (products). It will be carried out in a form of a checklist based on the following guiding principles developed from the Queensland Government (2020) and literature reviewed.

- a. Is the device/product/service new in the market?
- b. Does it deliver cost savings to the end-user?
- c. Does it have efficiency gains or competitive advantage?
- d. What type of innovation is it? Incremental, radical, disruptive, future, e.t.c.
Incremental, Breakthrough, transformational?
- e. What is the level of originality of innovations?

APPENDIX IX: Competitive institutions in technology innovations

1. Ahmed Shahame Mwindai Technical Training Institute
2. Aldai Technical Training Institute /
3. Bondo Technical Training Institute //
4. Bureti Technical Training Institute
5. Chuka Technical Training Institute //
6. Coast Institute of Technology /
7. Eldoret National Polytechnic ///
8. Kabete National Polytechnic /
9. Kaiboi Technical Training Institute //
10. Kenya Coast National Polytechnic ///
11. Kiambu Technical Training College
12. Kitale National Polytechnic /
13. Kisiwa Technical Training Institute /
14. Kisumu National Polytechnic /
15. Mathenge Technical Training Institute //
16. Mawego Technical Training Institute //
17. Meru National Polytechnic /
18. Michuki Technical Training Institute /
19. Mukiria Technical Training Institute /
20. Nairobi Technical Training Institute ///
21. Nkabune Technical Training Institute ///
22. Nyeri National Polytechnic //
23. Ollesos Technical Training Institute /
24. PC Kinyanjui Technical Training Institute //
25. Ramogi Institute of Advanced Technology /
26. Rift Valley Technical Training Institute
27. Sangalo Institute of Science and Technology /
28. Siaya Institute of Technology /
29. Sigalagala Technical Training Institute //
30. Thika Technical Training Institute /

Selected disciplines include mechanical, civil, building, ICT, electrical, food and beverage, applied sciences and general agriculture, electronics, automotive, building, hospitality and institutional Management,

APPENDIX X: Shapiro-Wilk Tests of normality

Test items	Shapiro-Wilk		
	Statistic	df	Sig.
The institution evaluates and acquires intellectual property rights for use in internal innovations	.851	77	.000
The institution has workshops for exploring ideas and obtaining feedback	.842	77	.000
It is important to consider knowledge of the market segment when you are innovating	.704	77	.000
The institution has an commercialisation of innovation committee	.916	77	.000
The institution has a business strategy for most innovative products	.879	77	.000
My innovative products have aesthetic looks to make them more viable for commercialisation	.740	77	.000
The cost of innovations make them viable for commercialisation	.813	77	.000
There exists challenges in drafting agreements (eg. MoU) with partners.	.832	77	.000
Is the approach to innovation market-need driven? Thus solves real-life problems?	.751	77	.000
Innovators in this institution are rewarded for coming up with commercially	.915	77	.000
The institution has a practice that innovation must have quality production for profit	.811	77	.000
The institution has a practice that innovation must be demand driven	.801	77	.000
The institution holds frequent meetings to discuss innovation and their commercialisation.	.907	77	.000
Is internal value addition affected by insufficient funding?	.754	77	.000
The institution has bought a few intellectual properties from other innovators to use in our institution	.903	77	.000
some of our intellectual property rights have been sold to innovators outside our institutions	.891	77	.000
The institution incorporates external research to add value to our innovations	.870	77	.000
This institution utilises internal research and development to add significant value to our innovations	.724	77	.000
Our institution's technical facilities have a positive influence in my effort/ability to commercialise my innovation.	.855	77	.000
The institution actively searches for collaboration	.871	77	.000
Our collaborators come by themselves to seek for our partnership	.901	77	.000
In accepting collaboration, we consider the following: resource base, intellectual resources of the collaborator, funding ability etc	.853	77	.000

This institution has adequate partnership with industries with regard to innovating for commercial purposes.	.907	77	.000
Collaborators bring resources in to this organisation	.895	77	.000
Most innovators in this institution are creative	.796	77	.000
Most innovators in this institution are enthusiastic about commercialising innovations	.841	77	.000
Most innovators in this institution are self-motivated to innovate	.756	77	.000

APPENDIX XI: Factor Matrix of questionnaire responses

		Factor Matrix^a						
		Factor						
		1	2	3	4	5	6	7
1.	The institution evaluates and acquires intellectual property rights for use in internal innovations	.083	-.275	.081	.369	.059	.001	.525
2.	The institution has workshops for exploring ideas and obtaining feedback	.532	.102	.231	-.055	.084	.224	.224
3.	The institution has an commercialisation of innovation committee	.399	.203	.028	.345	.104	-.168	-.017
4.	The institution has a business strategy for most innovative products	.383	-.088	.101	.178	.156	.049	-.018
5.	My innovative products have aesthetic looks to make them more viable for commercialisation	.400	-.556	.198	.304	-.133	.102	-.095
6.	The cost of innovations make them viable for commercialisation	.376	-.724	.196	.039	-.072	.124	.238
7.	Innovators in this institution are rewarded for coming up with commercially	.639	-.029	.073	-.182	-.045	-.291	.089
8.	The institution has a practice that innovation must have quality production for profit	.468	-.241	.016	-.076	.614	-.291	-.065
9.	The institution has a practice that innovation must be demand driven	.553	-.140	.458	-.131	.401	.009	-.239
10.	The institution holds frequent meetings to discuss innovation and their commercialisation.	.466	.298	.069	.225	.103	-.092	.322

11.	Is internal value addition affected by insufficient funding?	.257	-.201	-.295	.408	-.004	.057	-.363
12.	The institution has bought a few intellectual properties from other innovators to use in our institution	.328	.500	-.163	.323	.306	.238	.065
13.	some of our intellectual property rights have been sold to innovators outside our institutions	.549	.382	-.069	.134	.327	.267	-.094
14.	The institution incorporates external research to add value to our innovations	.780	-.174	.089	.009	-.042	-.207	-.165
15.	This institution utilises internal research and development to add significant value to our innovations	.547	.164	-.111	.446	-.410	-.337	.004
16.	Our institution's technical facilities have a positive influence in my effort/ability to commercialise my innovation.	.353	.496	.245	-.034	-.317	-.157	-.054
17.	The institution actively searches for collaboration	.768	-.171	-.106	-.256	-.141	-.129	-.056
18.	Our collaborators come by themselves to seek for our partnership	.684	.044	.110	-.140	-.235	.467	-.077
19.	In accepting collaboration, we consider the following: resource base, intellectual resources of the collaborator, funding ability etc	.665	-.244	-.372	-.095	-.209	.244	.010
20.	This institution has adequate partnership with industries with regard to innovating for commercial purposes.	.718	.190	-.471	-.250	-.083	.043	.127

21.	Collaborators bring resources in to this organisation	.833	.098	-.261	-.227	.014	-.076	.032
22.	Most innovators in this institution are creative	.132	.181	.366	-.404	.016	-.048	.180
23.	Most innovators in this institution are self-motivated to innovate	.211	.261	.761	.144	-.264	.091	-.137

Extraction Method: Principal Axis Factoring.
a. 7 factors extracted. 15 iterations required.

APPENDIX XII: Similarity report