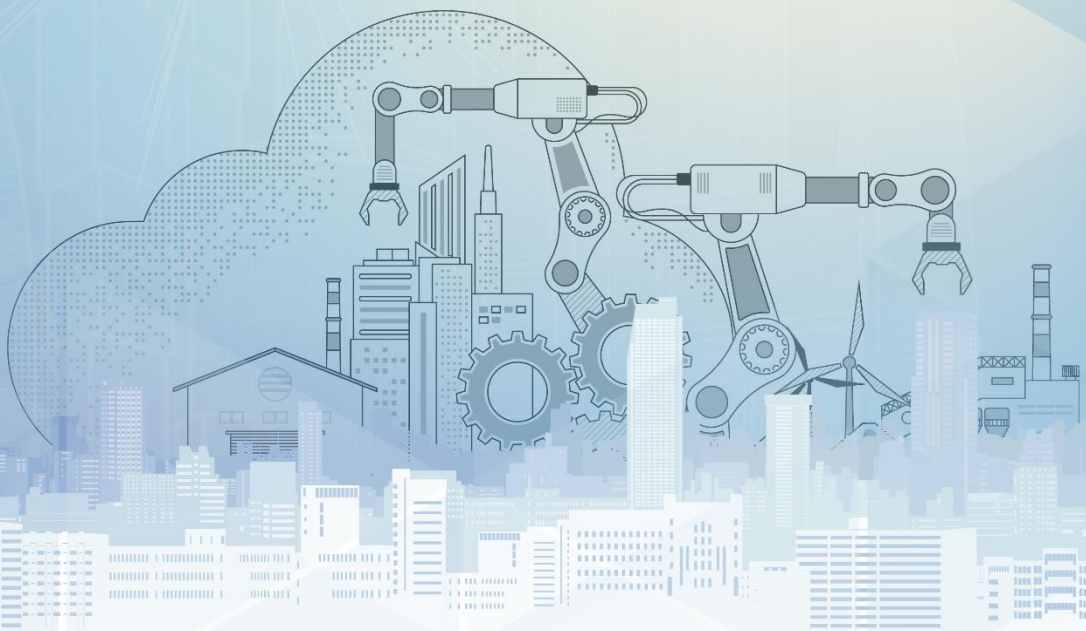
KINGDOM OF CAMBODIA

NATION | RELIGION | KING

Industrializing Cambodia:

Enterprise's Embracing Technological Advancement



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Foreword

The advancement of technologies has played significant role in human civilization. Society embracing science, technology & innovation (STI) reveals in resilient development and competitive advantage. Likewise, Cambodia has put in the priority agenda to harness the STI in her socio-economic development. Creating right portfolio to governance STI emerged in 2020 as seen the evidence of having responsible institutions in charge of the sector, namely Ministry of Industry, Science, Technology & Innovation (MISTI) and National Council of Science, Technology & Innovation (NCSTI). As senior minister and minister of MISTI and chair of NCSTI, I highly value this report entitled "**Industrializing Cambodia: Enterprise's Embracing Technological Advancement**". It is timely that all relevant stakeholders, especially the private sectors, academia, and policy makers, take their best understanding to tuning for the progress in their respective institutions.

The foundation of national innovation system relies substantially on the development and utilization of STI in the society. For these reasons, the adoption and transfer of technology has seen to beyond an accessory in public and private institutions. The structural transformation of STI ecosystem in the Kingdom of Cambodia is timely made to address the vision of Kingdom to become upper-middle income country by 2030 and higher income country by 2050. The core foundation of vision is to spin off Cambodia economic from labor intensive to technological-based development. The realization requires comprehensive efforts from right stakeholders in developing, integrating and implementing STI policy tools. From policy wise, stepping stones has been made available for line ministries and institutions to materialize the full potential of STI, including Cambodia's STI Roadmap 2030, National Research Agenda 2025, Technology Roadmaps, Technology need assessment, Mapping research and innovation, monitoring and evaluation framework and guideline for STI policy, and to name some. This report on "Industrializing Cambodia: Enterprise's Embracing Technological Advancement" must bring more insightful substances to all STI actors to enable favorable and vibrant environment to ensure knowledge and skill are nurturing in our society.

Last but not least, this scientific study informs us to mobilize more efforts in investing to technology development among enterprises. Within short and medium term, MISTI will do our best commitment in leverage technologies for our strategic and top sectors, while the investment on technology transfer from R&D is progressing for resiliency and long-

term development. I would like to reaffirm that technology adoption and transfer is undoubtedly critical for Cambodia. A special thanks to team authoring this report for timely contributing this important document.

Phnom Penh, 21 July, 2023

Senior Minister
Minister of Industry, Science, Technology & Innovation

Kitti Settha Pandita **CHAM Prasidh**

Acknowledgement

The report entitled **"Industrializing Cambodia: Enterprise's Embracing Technological Advancement"** address contextual understanding about the state of the art of technology adoption and transfer among enterprises in Cambodia. The findings serve as an insightful input to compliment the mission of private sectors, academia, and policy makers. The study was made possible by founding team from Department of STI Data Management of General Department of STI, MISTI. The study has received a great support from Dr. Kan Channmeta, Secretary of State of MISTI.

The participation in the survey as well as physical discussion in the form of focus group from 100 enterprises is unforgettable. It is noted that three major sectors including Agriculture, Manufacturing, and Trade & Service were chosen as respondent in this study. This study starting from ideation, planning, data collection and analysis till report writing and edition were supervised by Dr. HUL Seingheng, Director General of General Department of STI, MISTI.

A special thanks is to external peer reviewers and colleagues from Department of Technology Transfer and Department of Policy Monitoring, Inspection, and Evaluation of General Department of STI, MISTI for their inputs and comments.

Last but not least, the spiritual supports from leaders and administrative assistance from cabinet office of MISTI are indispensable to make this report ready for materialization by all relevant STI actors in the Kingdom of Cambodia and beyond.

Executive summary

By becoming increasingly aware of the importance of science, technology and innovation (STI), the government opted to establish the Ministry of Industry, Science, Technology & Innovation (MISTI), being transformed from the former Ministry of Industry and Handicrafts (MIH) on April 06, 2020 via sub-decree No. 48. The newly established Ministry allows the government to mobilize the human resources in STI to cultivate and nurture for having a sound and inclusive development through well coordination among governmental players, academia, research institutions, private sectors, and development partners. The royal government is strongly convinced that the industrial development from inclusion of STI is critical to realize the ambitious endeavor to be an upper middle-income country by 2030 and higher income country by 2050. Rapid development of technologies requires, small and medium sized enterprises (SMEs) to embrace transformation in regards to technology transfer and adoption to forge the supply chain in global market, leading to deter business resilience to grow. To address these challenges, the objective of this study is to complementarily:

- explore the technologies used in the three prioritize sectors namely agriculture, industries (manufacturing including SMEs), trade and services;
- investigate for better understanding on maturity levels details among firms;
- identify main barriers keeping firms from technology adoption and transfer;
- correlate human resources in firms and introduction of industrial technologies for innovation;
- trigger the transformation requirement among firms with STI as foundation of resiliency

In 2021 Cambodia's STI Roadmap 2030 was endorsed by the government. This policy instrument shows clearer directions after endorsement by the government on National Policy on STI 2020-2030. The roadmap highlights five important pillars including governance, human capital, research, collaboration, and ecosystem. The technology adoption and technology transfer hit well the pillar on research, collaboration, and ecosystem. Cambodia’s Innovation system is seen as a good trend. However, the challenges and weaknesses are seen as well in the positive trend. Government has placed many important directions as priority in the form of policy guidance to address the future technology adoption and transfer. For instance, the Cambodia Digital Economy and Society Policy Framework 2021-2035 has been established for building foundation, adoption, and transformation in the development agenda of the country. NCSTI has adopted several key documents for resilience growth. Some of the major’s directive documents include AgriTech Roadmap 2030, HealthTech Roadmap 2030, and EduTech Roadmap 2030. The AgriTech Roadmap aims at increasing productivity of agriculture commodities and high value-added

production/services for the global value chain through technology and innovation by 2030. The HealthTech Roadmap aims at integrating technologies and health to benefit individuals, communities, and the country to attain an integrated one health approach, multidisciplinary policy and governance for health technology, and strengthening research and knowledge sharing capacity. Other important initiatives including DigitalTech Roadmap, EnergyTech Roadmap, and TouristTech Roadmap are in the pipeline of development.

Study suggests that some important technologies and platforms are on demand by private sectors. They are Mobile-first strategy, Cloud-based solutions, IoT and sensor technology, Radio-frequency identification technology, Data analytics, and Cybersecurity. For agricultural enterprises operating between 3 to 5 years, efforts are to encourage for adoption and transfer for some important technologies including cloud technology, robotics, blockchain, and weather tracking for, while for those operating less than 2 years, steps must be taken to help them overcome the uncertainties and challenges in adopting new technologies. For manufacturing enterprises disregarding of their maturity level, special attention for adoption and transfer is for some needed technologies including M2M communication, Real time location systems and AR & VR, as they lead to improvements such as cost-effectiveness, reduced human error, and increased traceability. For trade and service enterprises, it is recommended that potential benefits from adoption and transfer is to quickly adapt to emerging technologies and re-evaluate their return-on-investment calculations. While it is true that the ROI for some technologies may initially appear low, it is important to consider the potential long-term benefits, such as increased efficiency, better customer service, and ultimately higher profits. Overall recommendation to the three sectors studied, it is suggested that enterprises are encouraged to have inhouse platforms in the forms of training and educational programs that reskill and/or reskill the workforce with the necessary knowledge and technologies with innovative-oriented approaches.

Having platforms of sharing knowledge and skill is indispensable for enterprises. The platform could be in named as “Technology Platforms” allowing stakeholders exchanges knowledge or technologies. Investment in R&D is a mean for resilient development of enterprises. Knowledge and innovative technologies made by the local responses correctly to local demand. Enterprises demands in the future for the right mix of fundamental, soft, and technical skill, especially digital and business-specific competence. Cambodia’s enterprises require a more competence workforces that are adaptable enough to new technical advancement. Knowledge capacity and available number of experts are paramount important to cope the demand of three sectors. On the other hand, the private sectors must join hand with educational institutions such as higher education institutions and technical and vocational training schools to address immediate demand through join curriculum development.

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List of Abbreviations

AFF	:	Agriculture, forestry, and fisheries sector
AGV	:	Autonomous guided vehicle
AMR	:	Automated mobile robot
AR/VR	:	Augmented/virtual reality
AR	:	Augmented reality
ASEAN	:	Association of Southeast Asian Nations
BIS	:	Business Intelligent System
COBOTS	:	Collaborative robot
CRM	:	Customer relationship management systems
CPS	:	Cyber physical system
CSDGs	:	Cambodia sustainable development goals
FDI	:	Foreign direct investment
GD/STI	:	General Department of Science Technology & Innovation
HRM	:	Human resource management software
IDP	:	Industrial Development Policy
ICT	:	Information and communication technology
IoT	:	Internet of Things
IIoT	:	Industrial Internet of Thing
IP	:	Intellectual property
IT	:	Information technology
IR 4.0	:	Industrial Revolution 4.0
ISIC	:	International Standard Industrial Classification
KPIs	:	Key performance indicators
MBOs	:	Management by objectives
MISTI	:	Ministry of Industry, Science, Technology & Innovation
MIH	:	Ministry of Industry and Handicrafts
M2M	:	Machine to machine
MSMEs	:	Micro small and medium-sized enterprises
NCSTI	:	National Council of Science, Technology, and Innovation
PLC	:	Programmable Logical Controllers
R&D	:	Research and Development
RFID	:	Radio-Frequency Identification
RGC	:	Royal Government of Cambodia
ROI	:	Return on investment
SDGs	:	Sustainable Development Goals

STI	:	Science, Technology and Innovation
SMEs	:	Small and medium-sized enterprises
SMEPC	:	SME Promotion Committee
TCO	:	Total cost of ownership
TVET	:	Technical and vocational education and training
VR	:	Virtual reality

1. Introduction

Cambodia comprises 25 provinces, as indicated in **Figure 1**. Cambodia is strategically located in the center of one of the world's most dynamic region, South-east Asia. Cambodia is part of the Southern Economic Corridor of the Greater Mekong Subregion, stretching from Ho Chi Minh City to Bangkok. In terms of strategic position, Cambodia has fully prepared its transportation infrastructure to facilitate domestic and trade with neighboring countries. As a result, trade with Vietnam and Thailand is growing rapidly. Kampong Speu is one among 25 other provinces in Cambodia. Geographically, it has an area of 7,017 square kilometers, bordering Kampong Chhnang and Pursat to the north, Phnom Penh (capital city of Cambodia) to the east, Kampot and Takeo to the south and Koh Kong to the west. The topography is variable from a large area of lowland paddy fields in the east to lowland/upland mosaics and upland forested areas in the west. Additionally, the highest mountain (Phnom Aural with 1,813m altitude) in Cambodia is located in the northernmost part of the province. The average temperature in this province is about 27 degrees Celsius; the minimum temperature is about 16 degrees. December and January are the coolest months, and the hottest is April. In addition, this province has good transport infrastructure to conduct business and engage in trade in Cambodia. The country shows that there are 5 high-quality national roads in the province.

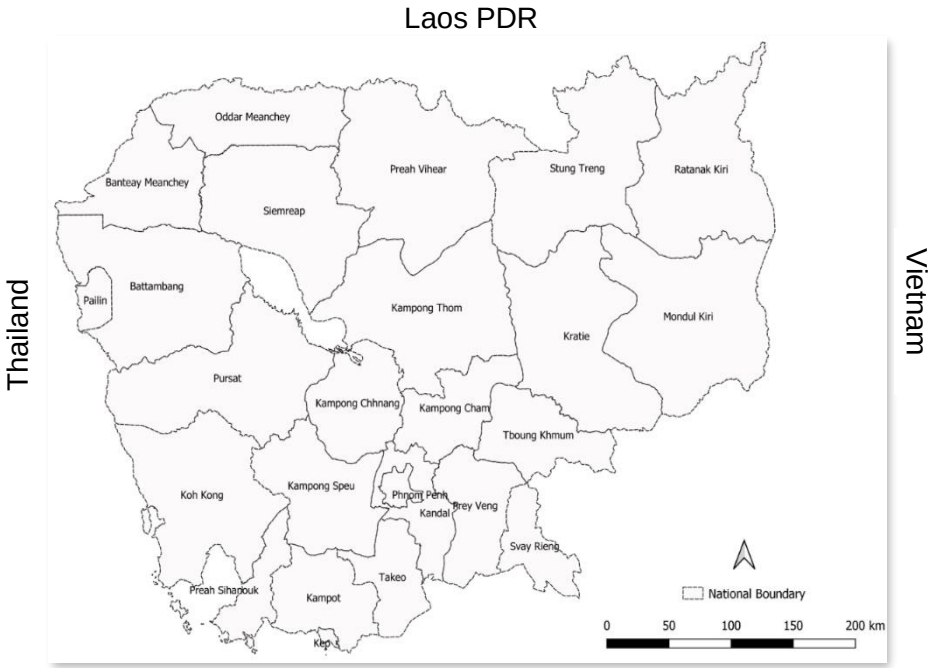


Figure 1. Overview full map of Cambodia provinces

The Royal Government of Cambodia (RGC) adopted the United Nations' 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) with a strong

commitment to their achievement. The CSDGs Framework 2016- 2030 then approved all 17 SDGs and included a new objective linked to land mine clearance and explosive remnants of war, reflecting Cambodia's national aim of de-mining its territory.

By becoming increasingly aware of the importance of science, technology and innovation (STI), the government opted to establish the Ministry of Industry, Science, Technology & Innovation (MISTI), being transformed from the former Ministry of Industry and Handicrafts (MIH) on April 06, 2020 via sub-decree No. 48. The newly established Ministry allows the government to mobilize the human resources in STI to cultivate and nurture for having a sound and inclusive development through well coordination among governmental players, academia, research institutions, private sectors, and development partners.

With the goal to transform the economy, the RGC has realized the role of STI in the economic growth, the initiative of this soft infrastructure has been created with a concrete duty and functions. Indeed, MISTI has just been transformed from the Ministry of Industry and Handicraft in time of pandemic due to the need for social-economic development in Cambodia. Moreover, MISTI also has just become the responsible national body as the National Council of Science, Technology, & Innovation (NCSTI) in October, 2020. The royal government is strongly convinced that the industrial development from inclusion of STI is critical to realize the ambitious endeavor to be an upper middle-income country by 2030 and higher income country by 2050. Based on the current trend of the socioeconomic development of Cambodia, it could be possible for the country to reach middle income in some years ahead. However, the vision beyond could face challenges. Thus, industrial innovation development has seen to be significant in graduating middle income level. Scientists have observed that most countries in the globe face a middle-income trap. And, the recommendation was to embrace innovation in industrial sectors. For instance, (Yülek, 2018) emphasizes that robust industrial policy is the way to graduate from the middle-income trap as shown in the figure below **(Figure 2).**

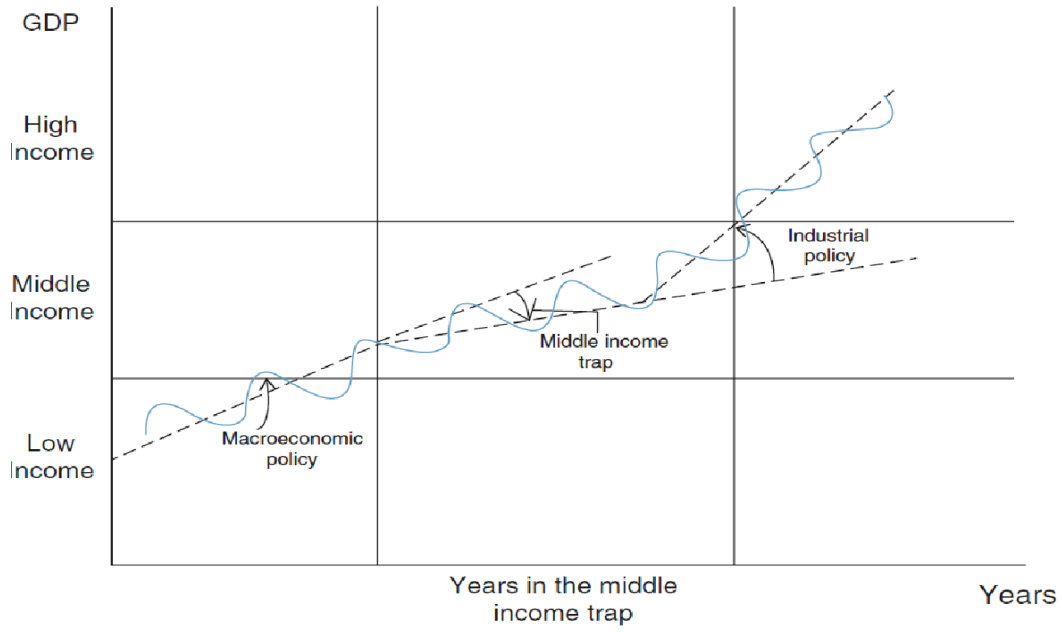


Figure 2. Industrial Policy and the Middle-income trap (Yülek, 2018)

Cambodia's localized goal, CSDG 9, intends to bring Cambodia's industries to life and promote them. The Industrial Development Policy (IDP) of the RGC outlines the ambition to convert and modernize the industrial sector from a labor-intensive to a skill-driven industry by 2025. Last few decades of economic development reveals that the industrial sector has played an essential role in promoting growth, employment, income, alleviating poverty, and integral part of the local economic transformation process. Currently, modern technology has led to fierce competition in the global market. In this competitive environment, the success of an enterprise depends on its ability to continuously improve its capabilities to find the most cost-effective way to meet the needs of customers and the market in terms of location, time, quantity, and quality. In addition, digital technology is an activation key in enhancing, transforming, and promoting business production lines, logistics, management system, access to innovative financial services, and many other international business activities, increasing productivity and economic efficiency by adopting and maximizing the benefits of information and communication technology (ICT) and emerging technologies.

According to “Cambodia Industrial Development Policy 2015-2025”, the industry in Cambodia consists of three leading sectors, including garment production, construction, and beverage processing sharing 42.4%, 30.1%, and 32.7% to GDP in 2013, respectively. Most industrial activities in Cambodia has seen in generally to be family-based and struggle to adapt and adopt the new technology to compete in the international market. In addition, technology may cause some adverse effects, including the loss of low-skilled labor, financial changes, and loss of privacy due to management. Besides, the vision of Cambodia for obtaining an upper-middle-income by 2030, and high-income status by 2050 can only be achieved if new technologies are leveraged to

increase industrial-value added, diversify exports, and strengthen small and medium-sized enterprises (SMEs). In 2021, Cambodia's STI Roadmap 2030 was endorsed by the government. This policy instrument shows clearer directions on national policy implementation, namely STI 2020-2030. The roadmap highlights five important pillars including governance, human capital, research, collaboration, and ecosystem. The technology adoption and technology transfer underpin the pillar on research, collaboration, and ecosystem. Briefly, research findings should be put to use in industry; efforts to foster collaboration should center on establishing technology platforms and university industry linkage offices; and the ecosystem should cater to the requirements of technology transfer and the strengthening of the intellectual property right regime. **Figure 3** below provides the brief detail of Cambodia's STI Roadmap 2030.

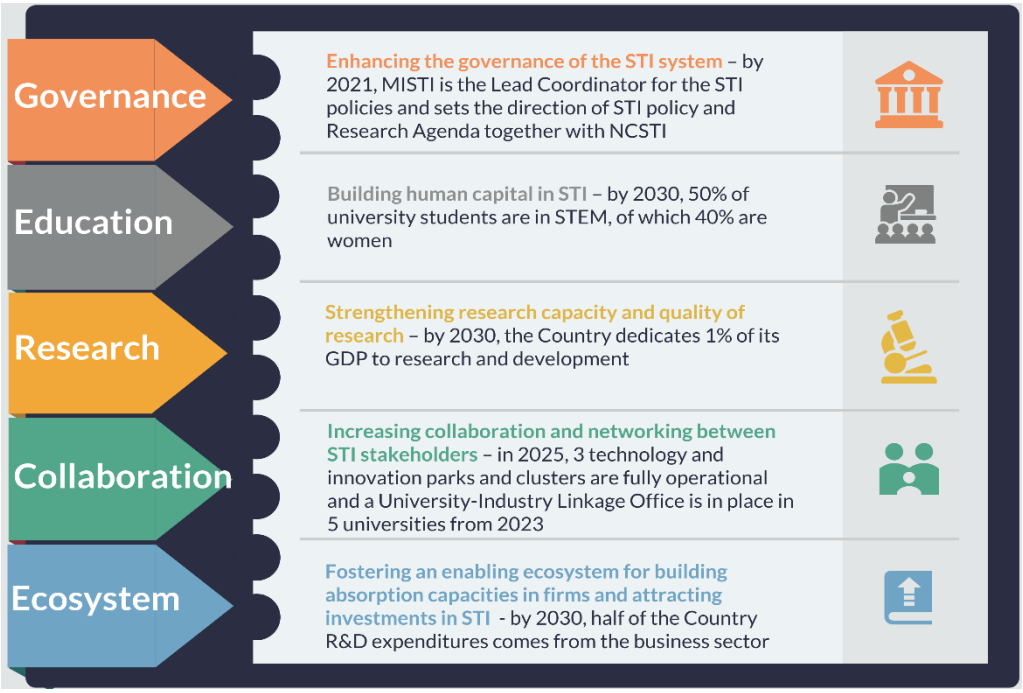


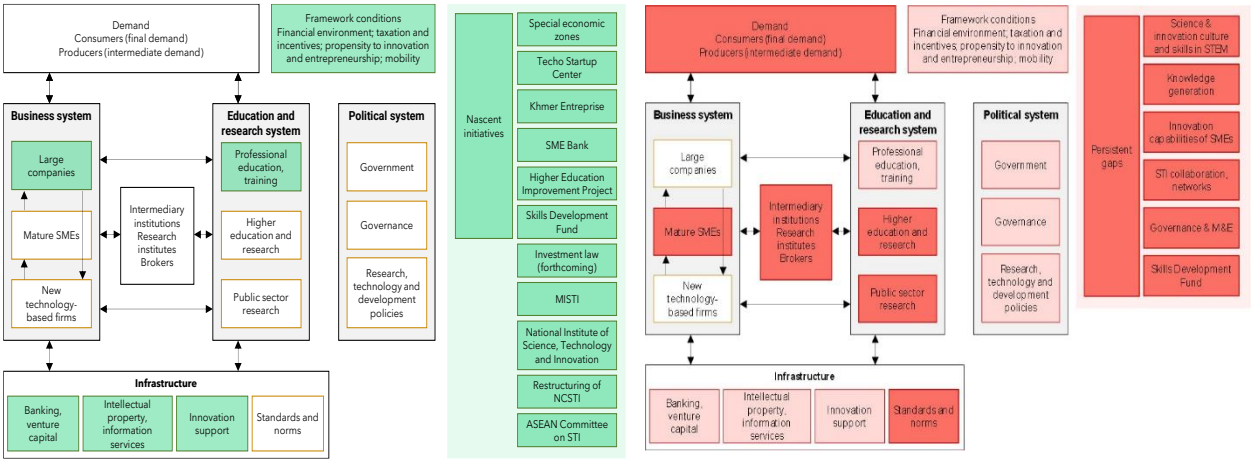
Figure 3. Five pillars of Cambodia's STI Roadmap 2030

To transform into a modern technology enterprise, an organization needs a fundamental shift in technology in general and in particular its core IT capabilities, the availability of practical technological infrastructure, and international economic connectivity. Thus, the preparation of digital platforms and databases are the core priority framework linking all aspects of the digital transformation across the industrial sectors. The enterprise's digital platform aims to build basic digital infrastructure, accelerate the adoption of digital technologies by enterprises and citizens in order to establish a universal digital platform that enables interaction between the public and private sectors, combines open access, and provides citizens with applicable digital technology-diversified data sources: laws and regulations, cyber security standards, and manufacturing technology and management.

Recently, there were several ways the COVID-19 pandemic affects the economy, especially SMEs, on both the supply and demand sides. On the supply side, companies experienced a reduction in the supply of labor, as movements of people were restricted. Measures to containing the disease by lockdowns and quarantines led to further and more severe drop in capacity utilization. Furthermore, supply chains were interrupted, leading to shortages of parts and intermediate goods.

On the demand side, a dramatic and sudden loss of demand and revenue for SMEs severely affected their ability to functioning, and/or caused severe liquidity shortages. Furthermore, consumers experienced loss of income, feared about contagion and heightened uncertainty, which in turn reduced spending and consumption. These effects were compounded because workers were laid off and firms were not able to pay salaries. Some sectors, such as tourism and transportation, were particularly affected, also contributing to reduced business and consumer confidence. More generally, SMEs were likely to be more vulnerable to 'social distancing' than other companies.

In dealing with the constantly changing business dynamics and the development of various developmental methods of doing the work, technology becomes one of the tools that are used to support the competitiveness of enterprises. In contrast to large scale businesses, SMEs have insufficient funds which restrict them from investing a large amount of funds for technology. Although many SMEs are involved in creative business, owners have not been able to understand the importance of the use of technology in the essential parts/functions of their business since there have seen limited knowledge on how beneficial this new sector is in increasing productivity among local SMEs. Since technologies, in terms of tools and skills, for SMEs are very constrained, SMEs could not adapt themselves to and survive in the pandemic situation. Therefore, conducting needs assessment and adoption of technologies and developing platforms for SMEs are critically important for them to be ready and to recover fast from vulnerable situations. It will be crucial to develop the Business Intelligent System (BIS) to support SMEs in real time for market access, technology adoption and scouting, and better understanding of the supply chain, and resiliency and competitiveness. It is noted market access is the main indicator of innovation. Cambodia's Innovation system is seen as a good trend. However, the challenges and weaknesses are seen as well in this positive trend. **Figure 4** below highlights the strengths in green color and weaknesses in brick color of Cambodia's innovation system.



a) Strengths in green boxes b) Weaknesses in brick color boxes

Figure 4. Cambodia's innovation system, a) strengths, b) weaknesses

Number of public actions have been done to address the severe impact on socio-economic development. For instance, the Cambodia Digital Economy and Society Policy Framework 2021-2035 has been established for building foundation, adoption, and transformation in the development agenda of the country (SNEC, 2021). Likewise, NCSTI has adopted several key documents for resilient growth. Some of the major directive documents include AgriTech Roadmap 2030, HealthTech Roadmap 2030, and EduTech Roadmap 2030. The AgriTech Roadmap aims at increasing productivity of agriculture commodities and high value-added production and services for the global value chain through the adoption of technology and innovation by 2030 (NCSTI & MISTI, 2022a). The HealthTech Roadmap aims at integrating technologies and health to benefit individuals, communities, and the country to attain an integrated one health approach, multidisciplinary policy and governance for health technology, and strengthening research and knowledge sharing capacity (NCSTI & MISTI, 2022b). The EduTech Roadmap aims at building the next-generation technology-enhanced learning ecosystem, focusing on improving innovation and entrepreneurship skills. The main objective is to rapidly incorporate technology into teaching and learning at home and school in order to assist children in acquiring the skills and knowledge necessary for a good education (NCSTI & MISTI, 2022c). Some other important initiatives including DigitalTech Roadmap, EnergyTech Roadmap, and TouristTech Roadmap are in the pipeline of development by NCSTI.

The industrial sector has played an important role in fostering growth, employment and income, and poverty alleviation; and is an indispensable part of the local economic transformation process. Major portion of Cambodia's GDP is from the sector. Currently, modern technology has led to fierce competition in the global market. In this competitive environment, the success of an enterprise depends on its ability to continuously improve its own capabilities in order to find the most cost-effective way to meet the needs of customers and the market in terms of location, time,

quantity and quality. In addition, information technology is intensively used to improve production, management, supply chain, and business strategies, transforming enterprises from a labor-intensive structure to a technology-intensive structure. In the competition of quality and variety, technology has become one of the most critical production factors in business life. Besides, the strategic location is also a key component to strengthen and facilitate the effective time, quantity and quality of logistics infrastructure.

Harnessing useful technology for innovation is timely and shall be in priority by all STI stakeholders, especially the private sector. The need to integrate domestic and foreign technology to boost manufacturing output was highlighted in quite a comprehensive report that consolidated the mandates and actions of STI actors in the country. (MISTI, 2020). In the regional view, digital transformation in manufacturing industries was emphasized as a priority agenda in 2021 for ASEAN during the 11th informal ASEAN Ministerial meeting on STI. The Joint statement by the ten ASEAN ministers on STI valued the key role of STI in industrial transformation and welcomed the on-going development of a consolidated strategy for the IR 4.0 (Joint Media Statement of the 11th Informal ASEAN Ministerial Meeting on Science, Technology and Innovation (IAMMSTI-11), 2021). The country needs to invest immediately in R&D mechanisms, and the transfer and acceptance of technology must be consistent with the initiatives (MISTI, 2021). Practices by most developed nations and theories teach us that investment in R&D is definitely the foundation for resilient, inclusive, and sustainable growth. Observation has shown that there is almost no single nation in the world that could graduate to the middle income without commitment in R&D. For instance, South Korea has pushed constantly and insensitively in research, which it turns into a result of being a major economic power in a few decades.

The Cambodian economy in 2020 was affected by the global crisis and was generally assessed to achieve negative growth of -3.1%, as illustrated in **Figure 5**, due to the decline in services and industry while the agricultural sector has maintained positive growth. At the same time, Cambodia continued to face key structural challenges, such as limited competition, slow economic diversification, and slow socio-economic digitalization (MEF, 2022).

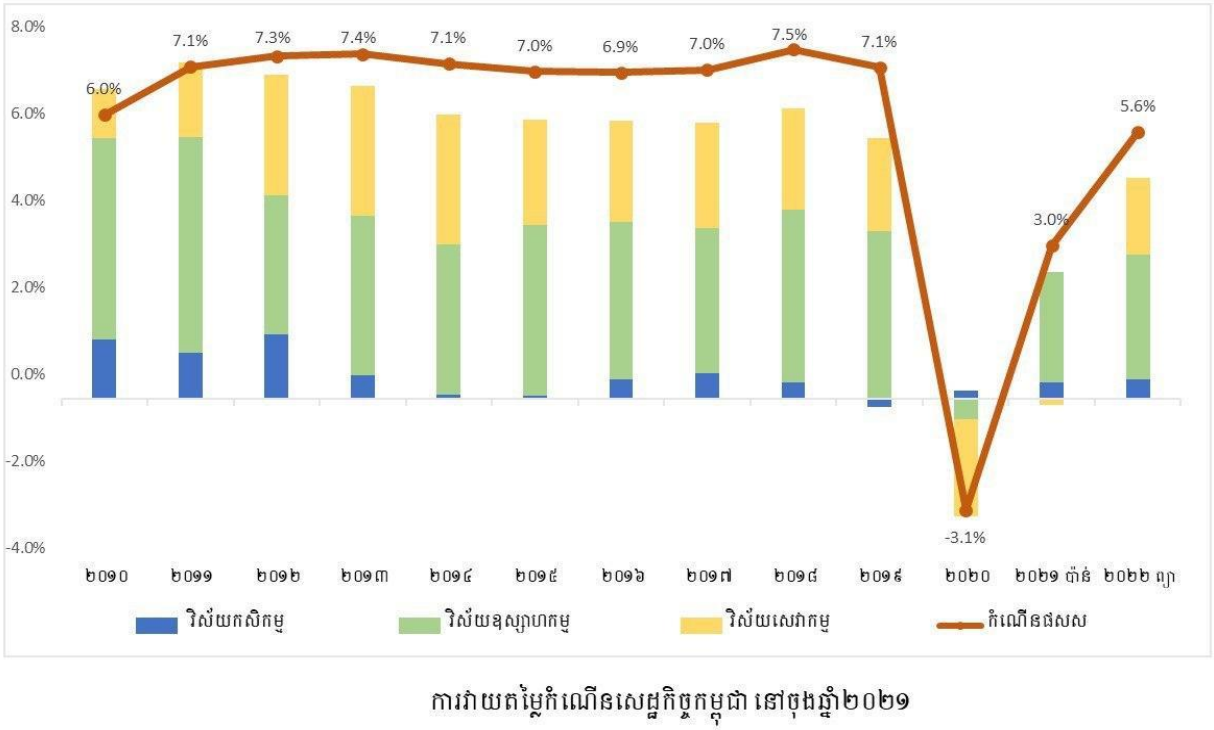


Figure 5. Cambodia Macro Economic Evaluation 2021 (MEF, 2022)

1.1. Objectives

Rapid development of technologies requires, small and medium sized enterprises (SMEs) to embrace transformation in/with regard to technology transfer and adoption to forge the supply chain in the global market, deterring business resilience from growing. To address these challenges, the objective of this study is to complementarily:

- explore the technologies used in the three prioritized sectors, namely agriculture, industries (manufacturing including SMEs), trade and services;
- generate better understanding on maturity levels details among enterprises;
- identify main barriers restraining firms from technology adoption and transfer;
- view human resources in enterprises and introduction of industrial technologies for innovation;
- provide suggestions to trigger the transformation requirement among enterprises with STI as foundation of resilience

1.2. Scope of study

The scope of this study is to set out in the domain of three sectors of macro-economic activities: agriculture, industry (manufacturing) and services with respect to the ISIC Rev4.0 classification as details below:

- Agriculture, forestry, and fishing (Section A: Division 1-3)
- Trade and service (Section G: Division 45-47; Section I: Division 55-56; Section K: Division 64-66)
- Manufacturing (Section C: Division 10-33)

The enterprise size aligns with the definition of small and medium enterprise (SME) status that has been newly defined and classified for the agricultural, industrial (manufacturing) and services and commerce sectors (see detail RGC No. 36 **សជ្ឈ**. **ហជ**, 2021).

The study design to gathering: (1) general information of company, (2) technology adoption and (3) technology transfer in Cambodia. In addition, the technical term adopted in this study is detailed in the attached file (see details, APPENDIX I).

2. Methodology

To take part in COVID-19 post-recovery, all developed and developing countries agreed that digital technologies could foster development resiliency. Since digital is a hopeful possibility to enhance socio-economic growth; therefore, understanding the maturity level among entreprises is crucial to set sound policy and further implementation plans. Meanwhile, the Ministry of Industry, Science, Technology & Innovation also produced Cambodia's STI roadmap 2030 during COVID-19 pandemic for supporting and strengthening the STI foundation, improving the STI environment, developing the STI ecosystem for sustainable development, and enhancing the quality of people's life (MISTI, 2021).

2.1. Sampling

The sampling method of the survey study generates sample size appropriate to explain the goal of firm performance analysis, focusing mainly on maturity, identifying barriers, and human resources that affect the productivity. A cluster random sampling is the whole population divided into clusters or groups. The cluster sampling is advantageous for researchers whose subjects are fragmented over large areas as it saves time and money (Scheaffer et al., 2011; Thompson, 2012). The study is designed in the form of probability sample in which each sampling unit is a collection or cluster of elements by each sector of economic activities such as manufacturing, agriculture, and services that have mainly contributed to Cambodia's economic growth (Cambodia's macro-economic and public finance policies, 2023). The population of SMEs/industry to be included in the study survey are based on the three main macro-economic areas.

The International Standard Industrial Classification (ISIC Rev.4) is an international reference classification of all economic activities. It provides a set of activity categories that can be utilized to collect and report statistics according to such industry activities. In 2005, Cambodia had a legal SME definition that was developed under the SME Development Framework. It classifies firms' size by including criteria of both employment and annual revenue return. In accordance with the result of the 2nd Meeting of the SME Promotion Committee (SMEPC) at the Council Ministers of Cambodia on January 21, 2021, a new scope of SMEs definition of SME was released by the government.

For each sector of economic activities, the study follows a small sample size, since the assumption of normality for a population isn't always realistic, and in many cases the population is neither normally distributed nor do we have knowledge about its actual distribution. However, the central limit theorem, provided that the sample size is large (i.e., $n \geq 30$) , the sampling distribution of the mean can still be assumed to be normal (Weiers, 2010). This is because of what is known as the central limit theorem for good sample data, the cluster random sampling will be applied to select the number of enterprises at least 30 SMEs/industries from the population. Hence, the study will consider a target sample size of around 100 in the survey study (see details, APPENDIX II).

2.2. Data collection

The study explores for deeper nuanced insights through the data obtained from Cambodia's National technology adoption and technology transfer survey, conducted by Department of STI data management, General Department of Science Technology & Innovation (GD/STI) of Ministry of Industry Science Technology & Innovation in 2022. Questionnaire design is the initial step of this research study. A questionnaire was started and developed according to the purpose and scope of the study. The data collection was divided into two different stages: (1) all participants from the three sectors were invited to participate in three different workshops, and in each workshop, relevant experts with advanced experience in using the technology application were invited to share with the participants. After the presentation, there were 30 minutes for the participants to complete the questionnaire and submit to the system; and (2) a direct field visit to the province at the industry.

2.3. Statistical analysis

The interim analysis presented here was intended to assist in the choice of decision making. All analyses were made in R (R Core Team). The categorical questionnaire, frequency values of participants' response were calculated in terms of n and % by performing a frequency analysis. Cross tables were produced to examine the relationship between the frequency values and the

variables. In addition, the Chi-squared test and Cramer's V test were added to each cross-table to highlight independence variables. For the numerical data, mean/median apply based on the normality of data and the confidence interval is reported to provide the information about a range in which the true value lies within a certain degree of probability, as well as about the direction and strength of the demonstrated effect. Additionally, p-value test enables the recognition of any statistical significance. The bar graph, pie chart, radar graph, and line graph are visualized to explain the shared percentage and the interaction among variables/rating scores. Survey data and individual/enterprises personal information are not disclosed due to privacy concerns. In principle, the study puts important attention to Research Ethics Guideline endorsed by NCSTI in 2022 (NCSTI, 2022).

3. Technology adoption and technology transfer

3.1. Technology adoption

Technology has changed the way business is done in almost every industry, including manufacturing, agriculture, trade and services. Cyber-Physical System (CPS) is one of the core systems, which is designed by applying the integration of computation, communication, and physical processes (Nasser, 2014) to perform high-value chain in the production line. At the heart of industry revolution 4.0 (IR 4.0) is the so-called smart factory, which involves the integration of IR 4.0 technologies in manufacturing factory processes (Chen et al., 2017). Besides, IR 4.0 may be considered as a business model based on the horizontal integration of CPS and smart technologies, vertical integration, in which big data collected from the shop floor and supply chain are managed through the different levels of the business, and end-to-end integration across the entire product life cycle (Chiarini et al., 2020). IR 4.0 technologies typically implemented in the manufacturing sector include the Industrial Internet of Things (IIoT), the cloud, automated mobile robots (AMR), autonomous guided vehicles (AGV), collaborative robots (cobots), analytics and AI, simulation, smart sensors and products, radio-frequency identification (RFID), additive manufacturing and augmented reality (Dalenogare et al., 2018; Kostrzewski et al., 2020). Additionally, IR 4.0 technologies have the potential to address environmental issues such as environmental sustainability (Bag et al., 2018; Stock & Seliger, 2016) the circular economy (Massaro et al., 2021) and green processes (Vrchota et al., 2020).

In recent years, Cambodia's economic growth has been concentrated in three main sectors: agriculture, manufacturing, and trade and services. To be precise, a technology adoption and technology transfer data collection survey has been conducted among SMEs to understand the technology application level in Cambodia. Quantitative expressive analysis of the collected data describes the ways in which businesses in Cambodia are operated mostly through the use of

mobile end device applications, which facilitate business processes. Additionally, three of the top technologies being implemented in business are customer relationship management systems (CRM), the Internet of Things (IoT) and labeling technology such as RFID, QR Code, etc., as indicated in **Figure 6**.

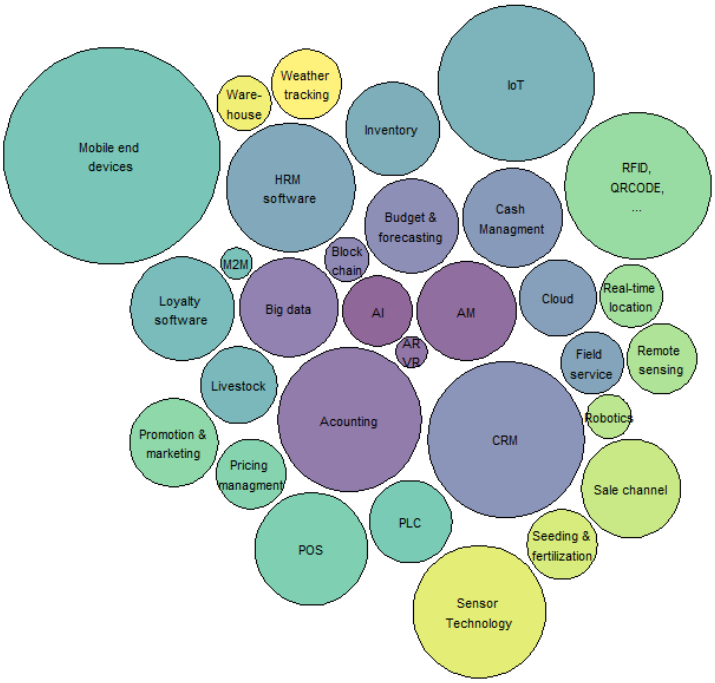


Figure 6. Technology Adoption in Cambodia

Typically, CRM helps businesses manage and analyze customer interactions and data throughout the customer lifecycle to improve customer service relationships and assist in customer retention and drive sales growth. A variety of companies leverage CRM systems to streamline their sales and marketing processes and enhance their customer relationships. The most common CRM systems[1] used by businesses in Cambodia include Hubspot, Salesforce, Perfex, and Meiqia, as shown in **Figure 7**. These systems are used by companies in various industries such as banking, insurance, retail, hospitality, and telecommunications, among others. The system brings together various customer data from different channels or points of contact between the customers and the companies, which may include the company's website, phone calls, live chat, direct mail, marketing materials, purchase history, buying preferences and concerns, and social networks. This brings in-depth insights into end-user applications and knowledge, enabling adoption of advanced digital platforms or systems for better business productivity and management.

IoT is one of the most-selected technologies in the study describing business technology usage. This technology enables connection and data exchange between objects, devices or systems

[1] https://trends.builtwith.com/analytics/crm/country/Cambodia

through the Internet or other communication networks. It is a core technology that transforms the hand-craft data exchange to smart M2M (machine to machine) communication. Additionally, as industrial environments grow in complexity, labeling technology becoming vital that can link all equipment correctly and can improve quality control procedures such as decreasing inspection time, decreasing data-entry errors, increasing traceability, managing warranties, saving costs, and optimizing their business. There are several companies that have successfully implemented IoT solutions in Cambodia, such as Smart Axiata[2] which has developed a Smart IoT system to enable users to remotely monitor and control their homes. Soramitsu[3] is a Japanese fintech company that specializes in developing blockchain-based solutions (e.g., Bakong) for various industries. While Soramitsu has not specifically developed an IoT-based payment system for Cambodia's rural areas, they have worked on blockchain-based payment systems that could potentially incorporate IoT devices. Other noteworthy, selected technologies are sensor technology, accounting software, and HRM software, being important and respectively related to logistic management and financial management in business.

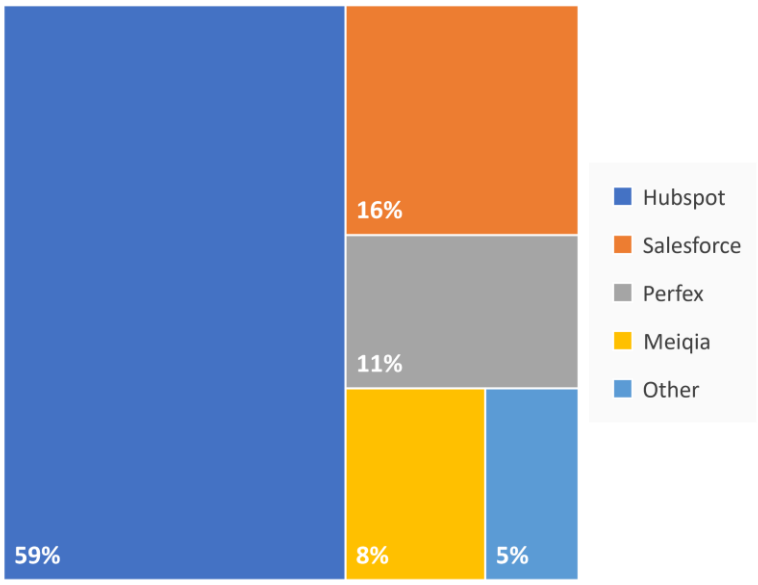


Figure 7. Statistics for websites using CRM technologies

At the present, some major technologies of IR 4.0 have appeared in precision agriculture and production agriculture. These technologies are 30.1% related to mobile end devices, 19.3% relevant to IoT, 8.4% to relabeling technology, 7.2% to livestock technology, 6.0% to remote sensing technology, 6.0% to artificial intelligence (AI), 6.0% to seeding and fertilization, and 6.0% to weather tracking as shown in **Figure 8**.

[2] https://www.smart.com.kh/get-smart/plans/smart-iot/

[3] https://soramitsu.co.jp/

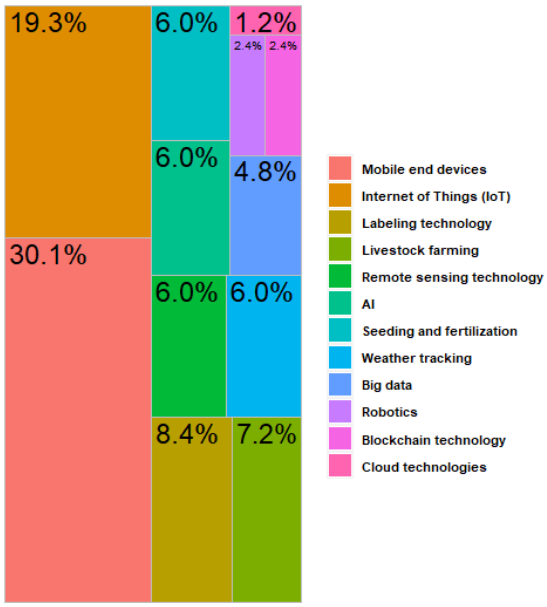


Figure 8. Technology adoption in Agriculture, Forestry and Fishing Sector

For manufacturing, enterprises surveyed technology adoption around 23.2% on mobile end devices, 18.2% on sensor technology, 15.2% on labeling technology, 10.1% on additive manufacturing, 9.1% on IoT, and 7.1% on a programmable logic controller (PLC), as illustrated in **Figure 9**. These major technologies are well known for stimulating full-body access applied to machinery.

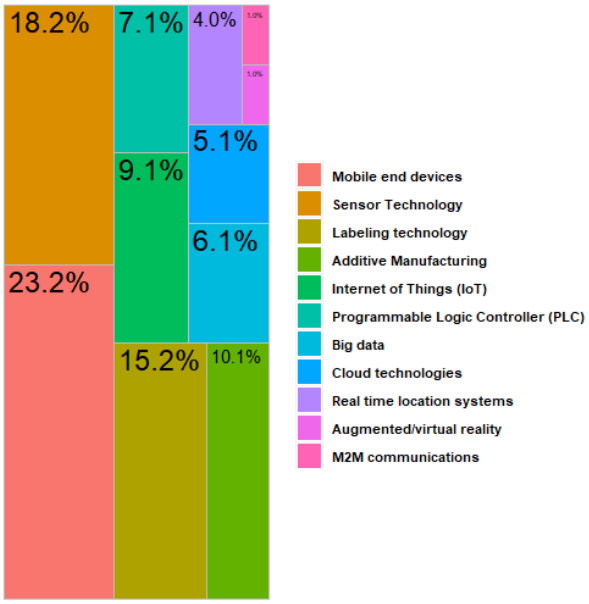


Figure 9. Technology adoption by manufacturing sector

For trade and service, the data is collected in three categories, including sale-related technology, operation technology, and finance-related software. The most talked about systems available, CRM was chosen by 17.2% for the study, accounting 14.5%, human resource management software (HRM) 11.7%, point-of-sale systems (POS) 9.0%, loyalty software 7.6%, sale channel

management and cash management 6.9%, inventory management and budgeting & forecasting software 6.2%, promotions and marketing software 5.5%, and pricing management 3.4%, as shown in **Figure 10**.

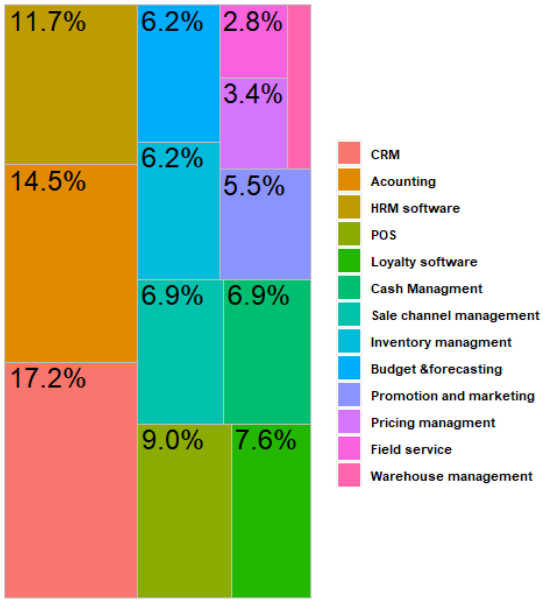


Figure 10. Technology adoption by Trade &Service sector

Likewise, the findings on annual revenue and enterprise operation are described in **Table 1**. According to the participants' responses, enterprises that have been operating for more than five years generate higher annual revenue, accounting for 22.0% with an annual revenue between USD 25K-USD 1,000K and 45.7% with an annual revenue of more than USD 1 million. Enterprises that operate between 3-5 years generate annual revenue between USD 25K-USD 1 million, accounting for 37.9%. Therefore, providing support to small and medium-sized enterprises to extend their operational life can lead to increasing revenue and provide them with the time needed to adopt new technologies that can improve their business processes.

Table 1. The interaction between the classification of annual revenue and the maturity level of enterprise operation in years.

Annual revenue	Enterprise Operation			Total
	Less than 2 Years	3 - 5 Years	More than 5 Years	
Less than 62,000$	6 30.0 50.0	5 25.0 17.2	9 45.0 15.2	20 100.0 20.0
62,001$ - 250,000$	4 20.0 33.3	6 30.0 20.6	10 50.0 16.9	20 100.0 20.0
250,001$ - 1,000,000$	0 0.0 0.0	7 35.0 24.1	13 65.0 22.0	20 100.0 40.0
More than 1,000,001$	2 5.0 16.6	11 27.5 37.9	27 67.5 45.7	40 100.0 40.0
Total	12 12.0 100.0	29 29.0 100.0	59 59.0 100.0	100 100.0 100.0

$\chi^2 = 12.447; df = 6; Cramer's\ V = 0.249; p - value = 0.069$

3.2. Technology transfer

The establishment of an intellectual property protection system and a mechanism to ensuring fair market transactions and a competitive environment creates an environment in which the deliverables of innovation such as technologies, knowledge and know-how, can be protected, accumulated and utilized. Micro small and medium-sized enterprises (MSMEs) and start-ups utilize their own technologies and business models, and engage in dialogues and collaborations with large companies and universities to co-create new value. An ecosystem is created in which companies and universities can be involved in a multi-layered manner regardless of their size. Additionally, technology transfer is a necessary strategy to ensuring the commercialization of a company's innovations.

Technology transfer allows SMEs to react to challenges, provides positive contribution to technological advancement, and expands their potential impact by increasing the dissemination of innovative products, promoting scientific, technological research, the associated skill and services for public benefit with external industry, investor and community partners.

Figure 11 shows that manufacturing sector has the form of transferred technology to foreign country at about 2.9% of the total number of firms surveyed, while agriculture and trade and services have not transferred technology abroad.

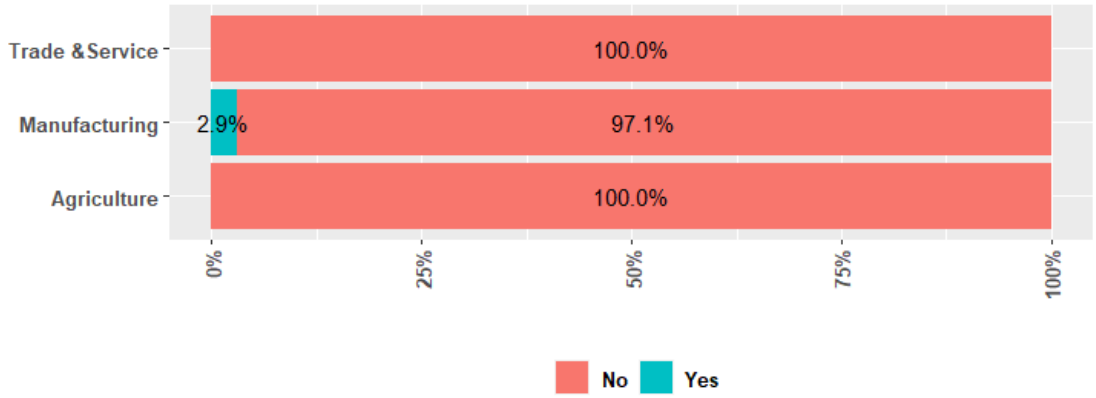


Figure 11. Technology transfer to foreign country

On the other hand, as indicated in **Figure 12**, the enterprises from different sectors such as manufacturing, agriculture, and trade and services have/possess the forms of transferring technology from abroad for 50.0%, 46.70% and 25.0% respectively.

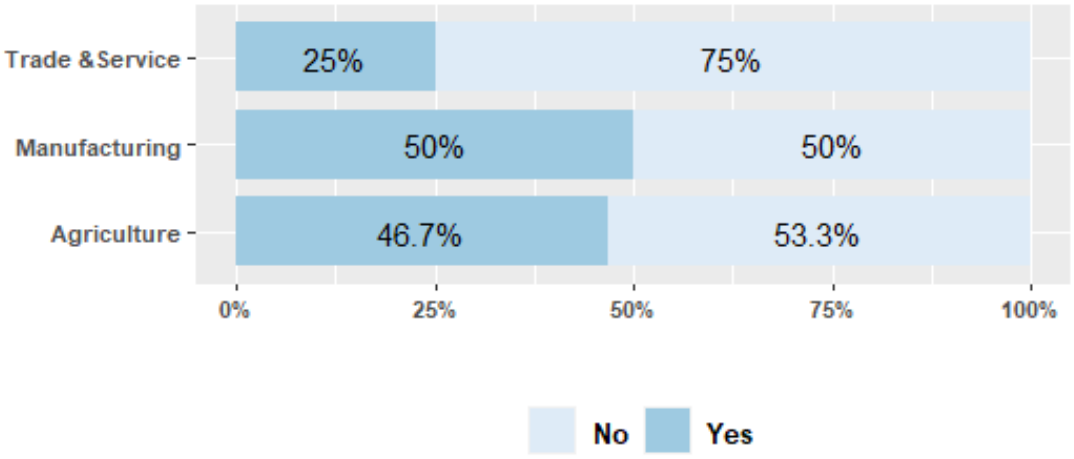


Figure 12. Technology transfer from foreign country

In **Figure 13**, the collaboration between enterprises in technology transfer is highlighted, with agriculture, manufacturing, and collaboration with other companies being the most common forms, accounting for approximately 50.0%, more than 50.0%, and 40.0% of the enterprises, respectively. Additionally, more than 40.0% of enterprises in the trade & services and agriculture sectors chose spin-offs as a common form of technology transfer, while the manufacturing sector contained approximately 25.0% that chose spin-off. Spin-offs play a crucial role in allowing SMEs to be more flexible in non-traditional ways of delivering services or products, making them an important tool in the technology transfer process. It allows a quick response to market needs and entrepreneurs are not inventors but hold right for the use of invention (Pomffyová et al., 2018). The rest of collaboration with less than 20.0% are university, research institution, incubator center and accelerator center.

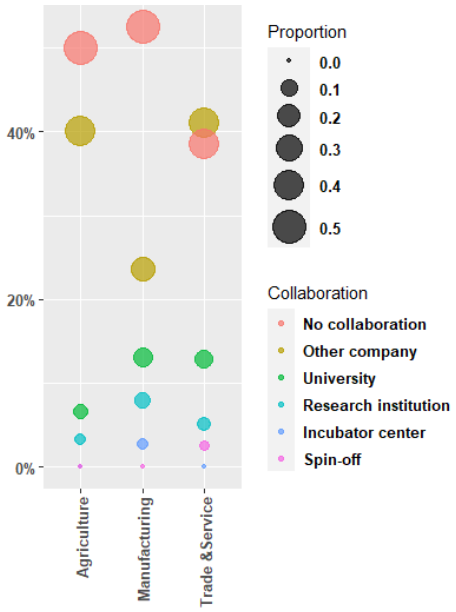


Figure 13. Collaborative on technology transfer

In addition, technology transfer in the form of licensing may be defined as the purchase, sale or exchange of certain rights relating to proprietary assets in which the licensor permits the licensee to make or sell products, use products or processes which involve invention (patent), special knowledge (trade secrets and know-how), names (trademarks), or the form or appearance of an original work (copyrights). It can be seen from **Figure 14** that the technology licensing regime has been mostly utilized by trade and service, and agricultural enterprises sector. An important characteristic of these licensing situations is that the technology contracts provide direct and indirect incentive for further innovation on the parts of the buyer. In contrast, manufacturing sector choose the most two potential regime of technology transfer other technology (20.0%) and followed by licensing (16.7%), management contract, foreign direct investment (FDI), buy-back contract (13.3%); and the least assignment IP (10.0%) and turnkey agreement (3.3%).

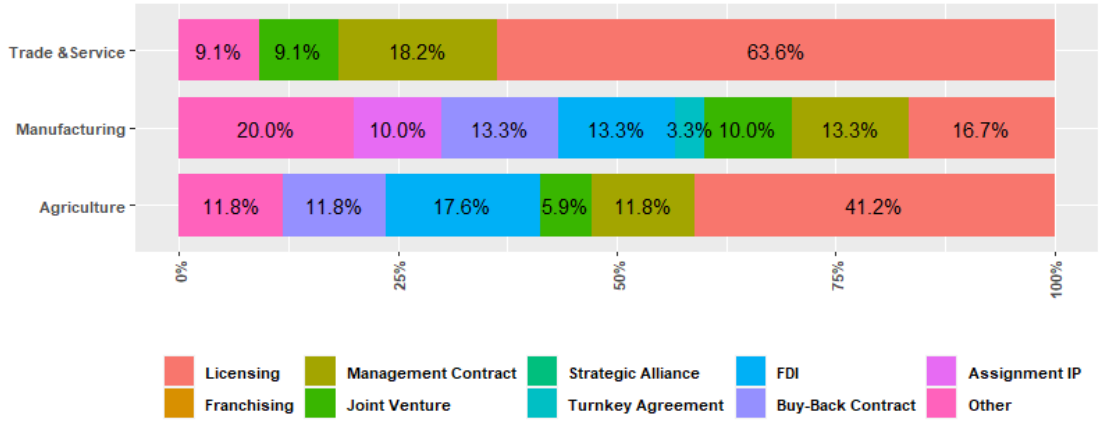


Figure 14. Technology transfer regime

In addition, the transfer of materials across companies is the most important type of transfer in the agriculture sector, as drawn in **Figure 15**. The trade and service sectors place the greatest emphasis on technology transfer to employees compared to the manufacturing and agriculture sectors. Manufacturing, by contrast, has primarily transferred technology to design types rather than other sectors.

Figure 16 indicates that the top form of technology transfer is training/seminar that applied for all sectors. Manufacturing sector, particularly, partnership agreement also most commonly adopts to improve and adjust contracts, structures, processes and routines, as well as to build support mechanisms and incentive to guarantee effectiveness in knowledge transfer (Milagres & Burcharth, 2019), while in trade and service applied licensing agreement to transfer of technology. Consequently, the provision of an information platform that reduces search and negotiation costs, as well as implementation costs such as shipping agreements, payments, insurance, and guarantees, can lead to a much wider range of customers being reached. This platform can help minimize the level of information asymmetry between both parties and ensure that they have

access to high-quality information for their transactional decision-making, ultimately leading to more successful and beneficial transactions.

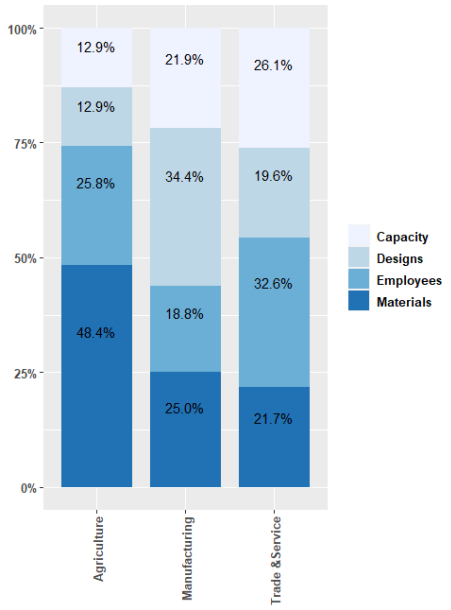


Figure 15. Type of technology transfer

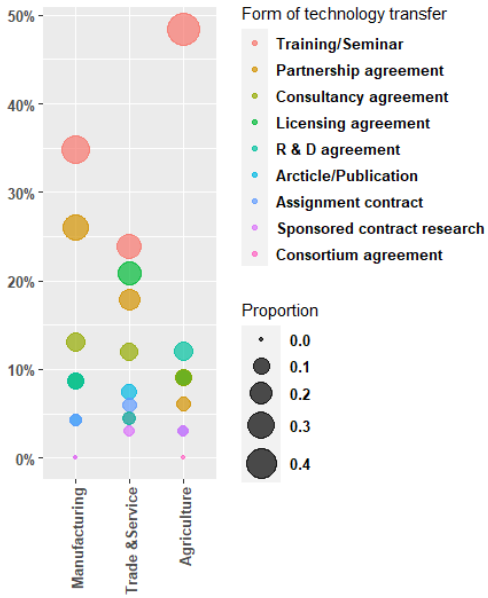


Figure 16. Form of technology transfer

A technology transfer office (TTO) is a specialized department within a university, research institute, or government agency that manages the transfer of knowledge, research outcome, and intellectual property from the organization to the commercial sector. The primary goal of a TTO is to facilitate the commercialization of innovations and discoveries made by researchers within the organization. TTOs provide a range of services, including identifying and assessing the commercial potential of inventions and discoveries, negotiating licensing agreement with industry

partners, protecting intellectual property rights, and providing guidance and support to researchers and inventors. By facilitating the transfer of technology from research institutions to the commercial sector, TTOs play a critical role in supporting innovation and economic growth, as well as in improving the quality of life through the development of new products and services. The TTO provides a range of services to support the transfer of technology from research institutions to the commercial sector. As illustrated in **Figure 17**, there are some keyways that TTO support process include:

- **Intellectual property protection** which helps researchers and investors protect their intellectual property through patents, trademarks, and copyright.
- **Training** is a process of acquiring new skills, knowledge, and attitudes through a structured learning experience. In the context of technology transfer, training can help researchers, inventors, and other stakeholders gain skills and knowledge they need to effectively commercialize new technologies and innovation. The training includes entrepreneurship, intellectual property, commercialization, researcher, and technology.
- **Legal support** is an important component of technology transfer, it helps researchers, inventors, and other stakeholders navigate the complex legal landscape surrounding intellectual property and comercialization. Legal support including licensing agreements, contract review, dispute resolution, and compliance.
- **Patentability** refers to the legal criteria that an invention must meet in order to be eligible for patent protection. In the context of technology transfer, patentability is an important consideration, as it can impact the commercial potential of new technologies and inventions.
- **Product development** is the process of taking an idea or invention and turning it into a commercially viable product that can be sold in the marketplace. The TTOs may support product development such as market research, prototyping, manufacturing support, regulatory compliance, and commercialization planning.
- **Access to debt financing** is an important consideration in technology transfer, as it can provide researchers, investors, and TTOs with the financial resources necessary to develop and commercialize new technologies and innovations.
- **Marketing potential, access to market, and marketing** refer to the revenue or sale volume that a product or service could achieve in each market. TTOs can play an important role in accessing markets and helping researchers and inventors identify the most promising commercialization opportunities.
- **Access to equity finance** can be an important aspect of technology transfer, particularly for startups and early-stage companies, looking to bringing new

technologies and inventions to market. Equity finance involves selling a portion of the company's ownership to investors in exchange for funding.

- **Analysis and evaluation** are key components of technology transfer, as they help to assess the commercial potential of new technologies and invention and inform decision on how to best bring them to market.

Access to emerging technology can be another key component to providing researchers and inventors with new tools and capabilities for developing and commercializing new technologies and inventions. It includes technology scouting, partnerships building, resource sharing, funding opportunities, and technology transfer agreements to support access to emerging technology.

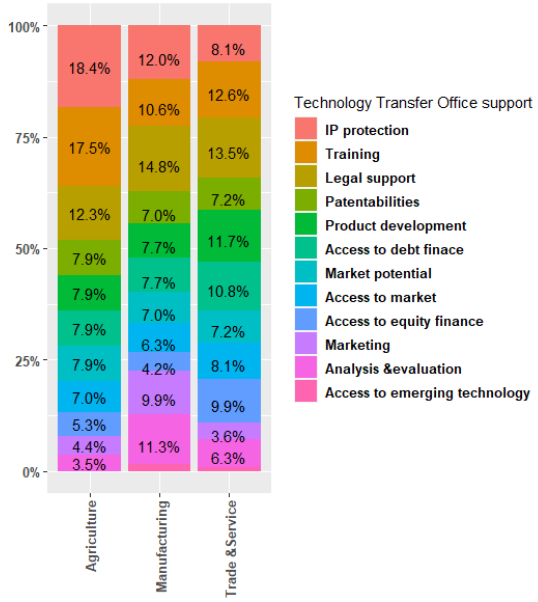


Figure 17. Support need from technology transfer office

As presented in **Figure 17**, in overall, most enterprises need IP protection, training, legal support, patentability, and other components that is necessary for TTOs to give support to enterprises, SMEs, researcher and inventors.

4. Classify maturity levels details

In today's rapidly evolving business landscape, technology plays a pivotal role in driving innovation, efficiency, and competitiveness. However, the adoption of technology varies significantly across enterprises relying on their maturity level. The maturity level of enterprise reflects its readiness and ability to leverage technology effectively to enhance operations, optimize process, and achieve strategic goals. Study proposed a roadmap on digitalization maturity model to assess the state of a company journey towards Industry 4.0 considering the following dimensions: strategy, process, technologies, product &services and people (Canetta et

al., 2018). In addition, other study also indicated five dimensions has been investigated on the maturity level including people capability, operation, technology driven process, digital support, and organization strategy (Chonsawat & Sopadang, 2019). Regardless of various dimension in factors identification, this study per Cambodia context examines the maturity levels enterprises in adopting technology, focusing on two factors: the age enterprises operation and the condition of the land condition they operate on.

4.1. Technologies being adopted based on the enterprise maturity level

4.1.1. Agriculture sector

The adoption of technology in the agriculture sector is influenced by various factors, especially the operating period of enterprises. The relationship between technology adoption and enterprise operating period in the agriculture sector can provide insight on the level of maturity and the willingness of agricultural sector to embrace new advancements as indicates in **Figure 18**.

The study finding indicated that agriculture enterprises with an operating period exceeding five years have incorporated various technologies into their business process. These technologies encompass cloud computing, robotics, livestock farming, mobile end devices, labeling technology, IoT application, big data analytics, whether tracking, and remote sensing technology. These technologies have been implemented by enterprise to enhance and facilitate their agricultural operations.

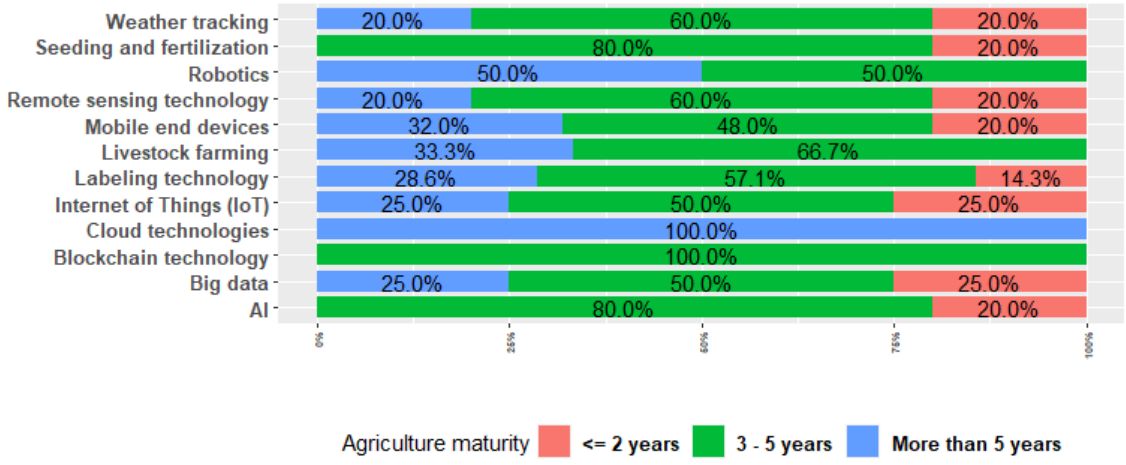


Figure 18. Technology adoption and enterprise operating period in the agriculture sector

For enterprises operating between three and five years, the majority of emerging technologies are being utilized. However, the adoption of cloud technology poses a challenge for SMEs during this period. In addition, the study reveals that enterprises operating for less than two years are adopting technologies such as remote sensing, mobile end devices, labeling technology, IoT, big

data, and aerial imagery. However, the implementation of cloud computing, robots, and weather tracking still presents some uncertainties and challenges for these enterprises.

Based on the **Figure 18**, a trend showing that agricultural enterprises with longer operating periods tend to adopt technology at a relatively higher rate compared to enterprises with shorter operating periods. This may suggest that the maturity level of longer operation provide a chance to consider the adoption technology in their business operation. For these reasons, mature enterprises should consider taking some advantage from emerging technology such as seedling and fertilization, blockchain technology and AI. Important policies as direction have been the foundation of resilient business ecosystem including Cambodia's STI Roadmap 2030, National Research Agenda 2025, and Cambodia AgriTech Roadmap. In addition, enterprises are suggested to work in hand with academia to acquired skill needs and materialize knowledge made by researcher.

4.1.2. Manufacturing Sector

The technologies adopted in the manufacturing sector were investigated in regard to its enterprise operating periods, as illustrated in **Figure 19**. For enterprises operating more than five years, the adoption of technologies as listed in the **Figure 19** are seen positively. Specifically, there are three technologies including real time location systems, machine-to-machine direct communication, and augmented/virtual reality (AR/VR), are being used among the enterprises.

On the other hand, enterprises operating within the three to five-year range have adopted sensor technologies, programmable logic controllers (PLCs), mobile end devices, labeling technology, IoT, cloud technology, big data, and additive manufacturing. The adoption of three specific technologies, as mentioned earlier, appears to be less prominent compared to more mature enterprises. In fact, these technologies hold significant potential for manufacturing enterprises to derive substantial benefits.

By incorporating PLCs, sensor technologies, and real-time location systems, manufacturing enterprises can make informed decisions that are both simplified and cost-effective, and leveraging machine-to-machine (M2M) communication capabilities (Laghari et al., 2021). Furthermore, the implementation of real-time location systems offers a range of advantages, including cost reduction, minimized room for human error, and the ability to track and trace items within a confined space (Rácz-Szabó et al., 2020).

In contrast, the enterprise operated less than or equal to two years tend to adopt technologies less than the enterprise operate exceeding two years. It is noteworthy that enterprises operated within the three to five-year range and exceeding five years tend to adopt technology than shorter

operation enterprise. For these reason, special attention from supporting wise should be made since the emerging enterprise could play a crucial role in driving innovation and enabling development of new products, and/or improving production techniques.

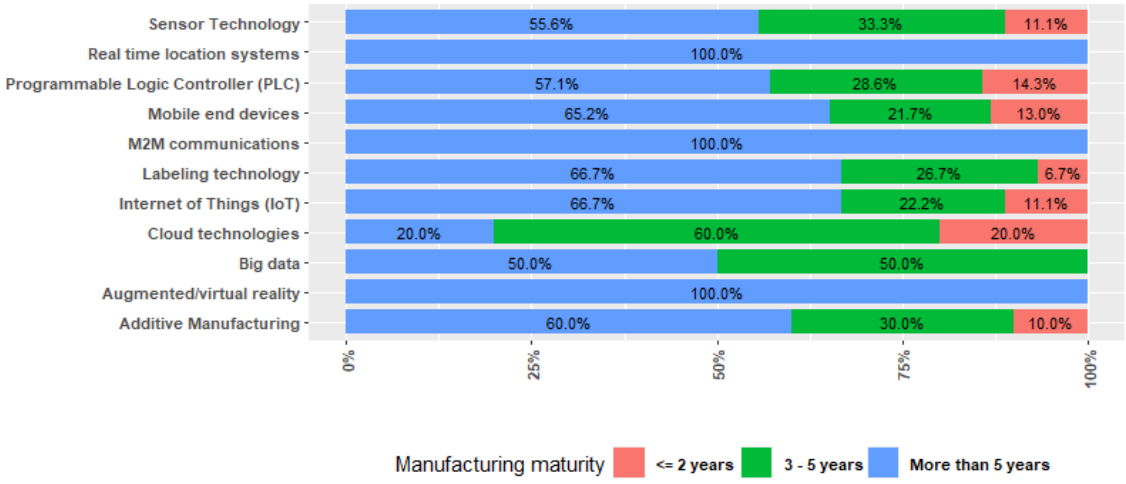


Figure 19. Technology adoption and enterprise operating period in the Manufacturing sector

Mature enterprises adopt all emerging technologies and require high qualification of school graduates for any troubleshoots in technological-based operation. Human resource development through technology transfer or accepting well-trained graduates from universities or technical and vocational education and training (TVET) is critical as foundation for industrial innovation. Emerging technologies are highly suggested to be embraced for enterprises operating less than or equal two years and in range of three to five years. Furthermore, it is convinced that those enterprises should quickly have the cooperation with academic sectors to acquire advancement of technology. It is also recommended to have critical investment for major technologies for early operated enterprises like Real time location systems and M2M communications.

4.1.3. Trade and Service Sector

In the trade and service sector, enterprises that have been in operation more than five years have been experiencing of adopting all types of technologies as shown in **Figure 20**. In contrast, enterprises that have been in operation for three to five years and less than two years seems not investing much in cutting edge technologies. Enterprises may perceive the return on investment (ROI) for technology adoption as too low to justify further investment (Passerini et al., 2012; Passerini, K., Tarabishy, A. E., & Patten, K., 2014).

Again, it is concludable that new operating enterprises should pay important investment in technological advancement in both form of collaborating with academia or similar business activities to upskill the employees.

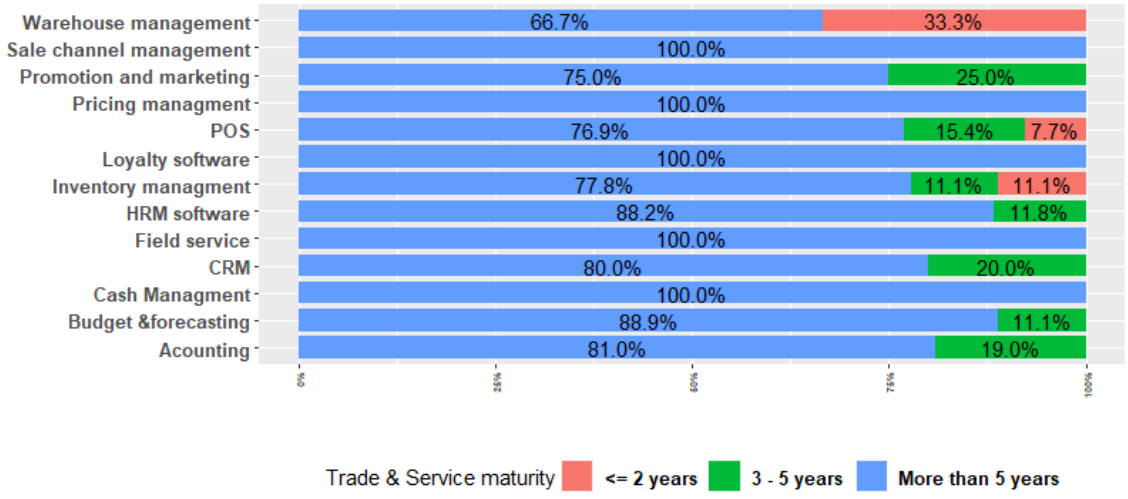


Figure 20. Technology adoption and enterprise operating period in the Trade & Service sector

4.2. Leased Land, Concession Land, or Private Land

Land use is an important factor to understanding the status of enterprises in the three sectors. There are three types of land ownership that are discussed in this report: leased land, concession land, and private land. Leased land refers to the owner of immovable property that may lease it out to another person. There are two types of these leases: a lease for an indefinite period of time and a lease for a definite period of time. The lease for a definite period of time includes a short-term lease with an option to renew and a long-term lease for fifteen years or more. Concession land refers to a legal right established by a legal document issued under the discretion of the competent authority, given to any natural person or legal entity or group of persons to occupy a land and to exercise thereon the rights set forth by land law. Concession land shall respond to a social or economic purpose. Concession land responding to a social purpose allows beneficiaries to build residential constructions and/or to cultivate lands belonging to the State for their subsistence. Private land, on the other hand, refers to land that is purchased by individuals or enterprise. A foreigner who falsifies national identity to become an owner of land in Cambodia shall be punished as determined under article 251 of the land law. Any property bought under these circumstances shall be seized as state property without compensation from the state. An enterprise registered in Cambodia, in respect of which 51.0% or more of the shares, are held by owners of Cambodian nationality or by Cambodian legal entities recognized in pursuant to the laws of Cambodia, is the owner of land (RGC, 2001, 2003).

As illustrated in **Figure 21**, the distribution of land use in the agriculture sector, with 46.7% operating on lease land, 36.7% on private land, and only 10.0% based on concession land. In the trade and service sector, the land use distribution shows that a majority of businesses rely on leased land, accounting for approximately 66.7% of the sector. A smaller portion of businesses, around 19.4%, have their own private land. The remaining 13.9% of businesses operate on land

categorized under other forms. The manufacturing sector, in contrast, the land use distribution shows that a significant portion of participants, approximately 52.9% operating on their own private land and nearly half of the company participants, around 47.1% using leased land for their operations.

Land is an important factor to enterprises in adopting technology, it is not just a physical location for doing business but also a convertible asset for mortgages in order to access to finance credit. Owning land provide several advantages, including complete control over land use and the ability to make long-term investment decisions based on that certainty. However, acquire land can indeed be challenging, particularly for new enterprise owner, due to the significant upfront capital require. Other solutions, as indicated in **Figure 21** enterprises can operate on lease land though its association with limited control and face some potential risk such as duration, rental fee, or restriction on land use. These factors can introduce uncertainty and risk for enterprises making it challenging to plan and invest on technology adoption in their operation with confidence. On the other hand, enterprises operating on concession land, which is land granted by government or their entities for specific purpose, may have a different technology adoption landscape. In some cases, concession may come with certain obligations or restrictions imposed by the granting entity. These obligations could include environmental sustainability requirements or social responsibility considerations, which may affect the type and scope of technology enterprises can adopt. Consequently, the maturity of technology adoption in among enterprises on concession land can vary based on the specific conditions and regulations associated with their land grant.

In the current situation, private landowners often have legitimate concerns regarding wastewater treatment and find it challenging to comply with Environmental, Social, and Governance (ESG) standard. Proper wastewater treatment is essential to mitigate pollution risks, protect water resources, and maintain the overall health and well-being of the community.

Consequently, the transitional economies can take some specific measures to create favorable conditions to encourage entrepreneurial activities and SMEs growth across various sectors of the economy. This measure can include the establishment of business cluster such science, technology & innovation park (STI park), special economic zones (SEZs), industrial cluster, and SME clusters that can foster linkages and networking for cooperation and promoting resource efficiency (Nguyen et al., 2008). Additionally, General department of Science Technology & Innovation (GDSTI) as a mandate from government bodies through the letter No. **ខ៣ សជណ.ឧប** should be prepared to provide regulatory frameworks and instruments that support and incentivize manufacturing SMEs operating within SMEs cluster, STI parks and/or High-tech Park. In addition, trade and service should put closer together can indeed result in improved service and efficiency.

By integrating trade and service activities, business can streamline operations, enhance customer experiences, and achieve greater efficiency.

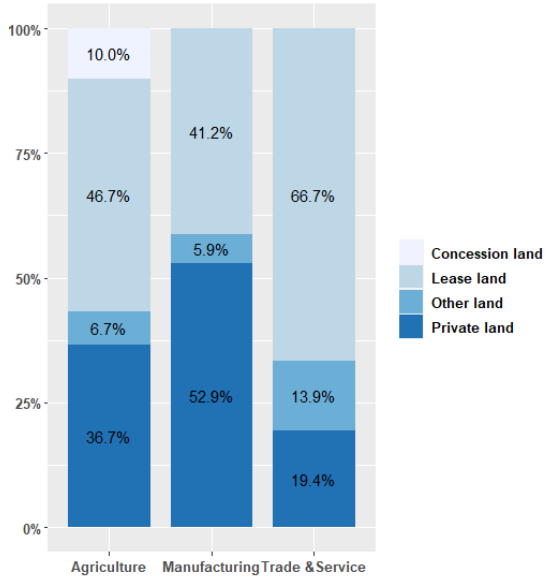


Figure 21. Land use by enterprises

5. Identify main barriers keeping firm from adopting and adapting

The adoption and adaptation of new technology is a crucial aspect of staying competitive in today's business world. However, firms can face various barriers that prevent them from embracing new technology.

Financial barriers are one of the most common obstacles that firms face. Investment in new technology often requires a significant financial commitment. Small or medium-sized enterprises (SMEs) may not have the necessary financial resources to invest in new technology. Moreover, the lack of available funding, high interest rates on loans, and complicated credit conditions can prevent firms from making crucial investments in new technology.

Regulatory or institutional barriers can also be a hindrance to adopting new technology. Government regulations can sometimes be excessively restrictive, making it difficult or even impossible for firms to adapt new technology in a practical manner. Additionally, bureaucratic procedures, such as obtaining permits or certifications, can take significant time and resources, leading to delays in technology adoption.

Technological barriers may also exist, such as the lack of available skilled personnel to operate new equipment, insufficient compatibility between current and new technology, or difficulties in

integrating new technology into existing systems. Firms that lack the necessary infrastructure also face significant barriers.

Finally, a lack of awareness and education on the benefits of new technology may prevent firms from embracing change. Resistance to change and a preference for the status quo can also impede progress towards adopting innovative approaches.

Otherwise, understanding the specific barriers that may impede the adoption and adaptation of new technology is essential for creating strategies to overcoming them. By identifying barriers and finding ways to address or work around them, firms can remain competitive and continue to succeed in an ever-changing business landscape (Butler & Sellbom, 2002).

5.1. Barriers of technology transfer in Agriculture, Manufacturing, Trade & Service

The adoption and adaptation of new technology by firms can be hindered by various barriers specific to each industry. In the agriculture sector, a poor understanding of intellectual property (IP) may prevent firms from investing or participating in technology transfer activities. Additionally, the insufficient funding for R&D and financial barriers can limit a firm's capacity to invest in new technology. In the manufacturing industry, legal and regulatory barriers can impede the adoption of new technology. For example, strict government policies regarding the use of certain technologies may hinder firms from adopting them. Furthermore, a lack of awareness or understanding of IP can also restrict innovation and adoption of new technologies. Similarly, for the trade and service sector, a lack of investment in R&D can limit the innovation and adoption of new technologies. Financial barriers may prevent firms from adequate investing in technology, while lengthy bureaucratic procedures can slow down the process of technological adoption. Additionally, strict government policies and regulations can also hinder the adoption of new technologies in this industry (Patanakul & Pinto, 2014).

In addition, it is essential for firms to understand the specific barriers in their respective sectors in order to create effective strategies to overcoming them and promoting the adoption and adaptation of new technology. Through innovative approaches and strategic investments in R&D, firms can stay competitive and remain at the forefront of technological advancements.

Based on the survey results in the agricultural, manufacturing, trade and service sectors in Cambodia, the following five key issues are the main barriers to technology transfer, as shown in **Figure 22**:

- Poor understanding of IP: The lack of understanding of Intellectual Property (IP) laws is identified as a significant obstacle to technology transfer in Cambodia. This is because IP law plays a vital role in protecting innovative ideas and inventions, making them more attractive to potential investors.
- Low R&D investment: The low investment in R&D is another obstacle that restricts the technology transfer process. Limited R&D investment in developing technologies, products, and processes makes businesses less competitive globally.
- Financial barriers: Accessing funding for technology transfer is a significant challenge in Cambodia. The lack of financial resources, inadequate funding models, and limited access to venture capital restricts the growth of innovative technology firms.
- Law and regulations: The government should simplify and integrate laws and regulations to encourage foreign direct investment and promote innovation in Cambodia.
- Bureaucratic procedures: Delays in the approval process for technologies, products, and services can be cumbersome for businesses. The government should take steps to streamline the approval process to improve the efficiency of technology transfer in the country.

Figure 22 shows that the top barrier to technology transfer across all three sectors is "Poor understanding of IP". However, the percentage varies from 29.4% in Agriculture sector to 45.0% in Manufacturing sector and 20.7% in Trade & Service sector. In terms of "Low R&D investment", it is the second most common barrier in Agriculture and Trade & Service sectors, with 23.5% and 22.4% respectively. Whereas, in Manufacturing sector, it is only 15.0%. "Financial barriers" is the third most common barrier in Agriculture and Trade & Service sectors, with 20.6% and 22.4% respectively. However, in Manufacturing sector, it is only 10.0%. "Law and regulations" is the fourth most common barrier in Manufacturing sector with 30.0%, while it is only 14.7% in Agriculture sector and 19.0% in Trade & Service sector. Lastly, "Bureaucratic procedures" is the only significant barrier in Agriculture and Trade & Service sectors with 11.8% and 15.5%, while they are not major issues in Manufacturing sector.

However, the survey results suggest that each sector has its own unique set of barriers to technology transfer, but "Poor understanding of IP" is consistently the top challenge across all sectors.

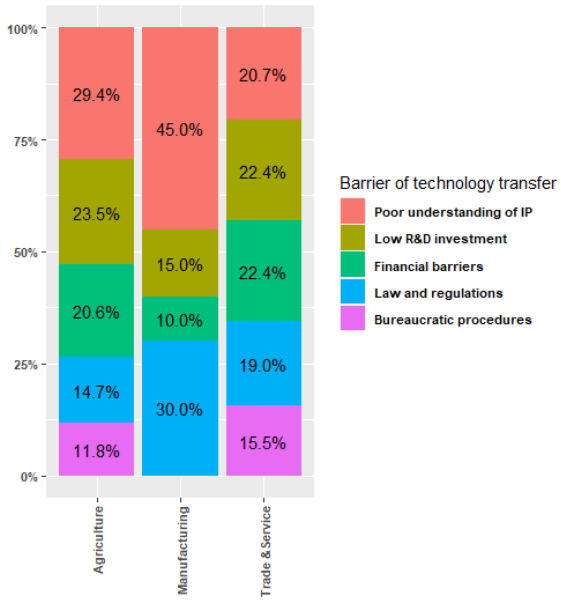


Figure 22. The Barriers of Technology Transfer in Agriculture, Manufacturing, Trade and Service

- Agriculture: According to the results of the survey on barriers of technology transfer in the agricultural sector in Cambodia, which is shown in **Figure 22**, the most significant barrier is a "Poor understanding of IP," with a percentage of 29.4%. This indicates that farmers and stakeholders may not fully understand the importance of protecting their intellectual property rights when they develop new technologies or products. The second major barrier, according to the survey, is "Low R&D investment," with a percentage of 23.5%. This means that investment in R&D in the agricultural sector in Cambodia is not as significant as it needs to be to drive technological innovation and progress. The "Financial barriers" were identified as a significant challenge by 20.6% of the respondents. This suggests that financing technological innovations in the agricultural sector can be challenging, particularly for small and medium-sized farmers. The "Laws and regulations" were identified as a barrier to technology transfer by 14.7% of respondents. This indicates that bureaucratic and regulations may hinder the transfer of new technology in the agricultural sector in Cambodia.

  Finally, "Bureaucratic procedures" were identified as a challenge by 11.8% of respondents. This means that complex bureaucratic processes and hurdles in acquiring licenses or permits can stand as obstacles in the way of technology transfer in the agricultural sector in Cambodia.

- Manufacturing: According to the results of the survey on barriers of technology transfer in the manufacturing sector in Cambodia, which is shown in **Figure 22**, the most significant barrier is a "Poor understanding of IP," with a percentage of 45.0%. This indicates that stakeholders in the manufacturing sector may not fully understand the

importance of protecting their intellectual property rights when they develop new technologies or products. The second major barrier, according to the survey, is "Law and regulations," with a percentage of 30.0%. This means that bureaucratic and regulations may hinder the transfer of new technology in the manufacturing sector in Cambodia. The "Financial barriers" were identified as a significant challenge by only 10.0% of the respondents. This suggests that financing technological innovations in the manufacturing sector may be less of a challenge compared to the agricultural sector in Cambodia. The "Low R&D investment" was identified as a barrier to technology transfer by only 15.0% of the respondents. This indicates that investment in R&D in the manufacturing sector in Cambodia is slightly better than the agricultural sector. It is noteworthy that the percentage of "Poor understanding of IP" in the manufacturing sector is significantly higher than in the agricultural sector, indicating a need for greater emphasis on intellectual property protection in the manufacturing sector.

- Trade and Service: According to the results of the survey on barriers of technology transfer in the trade and service sector in Cambodia, which is shown in **Figure 22**, the most significant barriers are "Low R&D investment" and "Financial barriers," each with a percentage of 22.4%. This indicates that investment in R&D and financing technological innovations in the trade and service sector in Cambodia are significant challenges. The "Poor understanding of IP" was identified as a barrier to technology transfer by 20.7% of the respondents. This suggests that stakeholders in the trade and service sector need to be educated on the importance of intellectual property protection when developing new technologies or products. The "Laws and regulations" were identified as a challenge by 19.0% of the respondents. This means that bureaucratic and regulations may hinder the transfer of new technology in the trade and service sector in Cambodia. The "Bureaucratic procedures" were identified as a challenge by 15.5% of respondents. This means that complex bureaucratic processes and hurdles in acquiring licenses or permits can stand as obstacles in the way of technology transfer in the trade and service sector in Cambodia.

  In addition, the Trade and Service sector faces similar barriers as the agriculture sector, with investment and financial barriers presenting a significant challenge. However, the percentage of "Poor understanding of IP" is significantly lower, suggesting a better understanding of intellectual property protection in this sector.

6. Map human ability on industrial technology and innovation

6.1. Competencies of Industry 4.0 Skills

Industry 4.0 refers to the integration of automation and computing technologies in a way that fundamentally transforms industrial processes and operations executed by human operators. It combines various technologies such as CPS, IoT, and cloud computing to create a more connected and efficient manufacturing environment. The applied technology is predominantly based on technologies include autonomous robots, system integration, IIoT, simulation, additive manufacturing, augmented reality, cloud computing, big data, AI, information transparency with cybersecurity, sensor and digital twin simulation models (Kaur et al., 2020; Wrobel-Lachowska et al., 2019). These technologies will be used by organizations to manufacture smart products and services and employees will have to adapt to using the technologies.

Furthermore, it further assures that employees are adaptable in multiple dimensions for the successful implementation of advanced technologies. The ability of employees to handle such dynamic work situations will be an important aspect of the success of advanced technologies. Previous research on employee adaptability has shown that individual employees vary in their ability to adapt in such dynamic work environments. In addition, the ability to adjust behavior to the demands of new circumstances, situations, or events is the primary requirement for employee adaptability. Another thing to consider is that a lack of skills can slow down the benefits of Industry 4.0 technologies, which can affect a company's performance. Most companies that implement digital transformation fail to capture the full business opportunities presented by new technologies. Some of the challenges that the organizations face in scaling digital transformation are a lack of strategic direction on how digital manufacturing can deliver real business value, a lack of required technology, management and transformation capabilities, and a lack of robust data and IT infrastructure. Moreover, as indicated in **Figure 23**, skill competence challenges that most enterprises are facing are the availability of local expertise in terms of knowledge capability, experience, professional attitude and highly productivity rate. The following skill competencies defined by its term as below:

- Availability of expertise refers to a person who has a high level of knowledge, skill, and experience in a particular field of subject matter.
- Knowledge capacity includes the ability to acquire new knowledge through learning, research, and experience, as well as the ability to retain and organize the knowledge for future use.

- Experience is an essential aspect of human learning and development, providing individuals with the knowledge and skills they need to navigate complex and challenging situations.
- Professional attitude refers to a set of behaviors, values, and beliefs that are commonly associated with a professional work environment. It includes the range of reliability, accountability, respect, ethical behavior, and a commitment to ongoing learning and development.
- High productivity rate refers to the level of output or work accomplished in a given period of time, typically measured in terms of quantity, or efficiency. A high productivity rate indicates that an individual or enterprise is able to achieve a significant amount of work output even though using minimal resources, time, or effort. There are six components contributing to high productivity rate including effective time management, clear goals and objective, quality of work, efficient processes, and systems, focus and concentration, and continuous improvement.

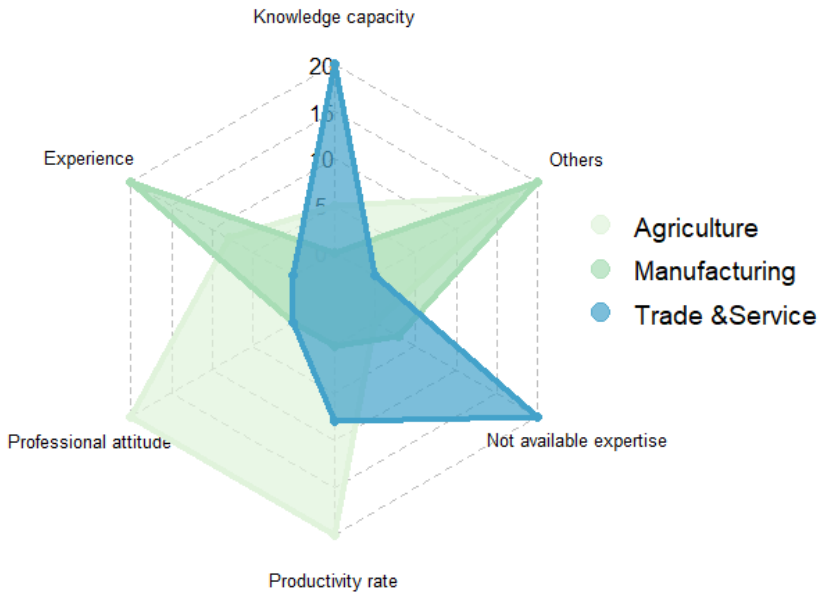


Figure 23. Barrier as a frequency to recruitment of local expert

In the agriculture sector, the skill competence of productivity rate, professional attitude, and others are as high as the enterprise's need for placing staff in a certain position. A high productivity rate can bring many benefits to an individual or organization, such as increased profitability, improved competitiveness, greater job satisfaction, and a stronger sense of accomplishment. In addition, a professional attitude can create a positive and productive work environment, build strong working relationships, and contribute to the success of the organization. It can also lead to increased job satisfaction, improved opportunities for career advancement, and a greater sense of personal and professional fulfillment.

The manufacturing sector, emphasizes on experience, and other skill competencies followed by not available expertise, productivity rate, and knowledge capacity to hold a specific position. This overall competence is essential for a future job that requires each specific skill that a member of staff obtained from their degree. Lastly, trade & service sectors clearly indicate that not available of experts, knowledge capacity, and productivity rate and follow the professional attitude, experience, and others to place in a specific position.

In addition, **Figure 24** illustrates that four competencies cover top 9 skills adopted from (Grzybowska & Anna, 2017; Kate Whiting, 2020). The jobs of the future will require the right mix of fundamental soft- and technical- skills, especially problem-solving including (a. Analytical thinking and innovation, b. Complex problem-solving, c. Creativity, originality and initiative, d. Reasoning, problem-solving and ideation); self-management (a. Active learning and learning strategies, b. Resilience, stress tolerance and flexibility); working with people (Leadership and social influence); digital technology use (a. Technology use, monitoring and control, b. technology design and programming) for a business-specific need.

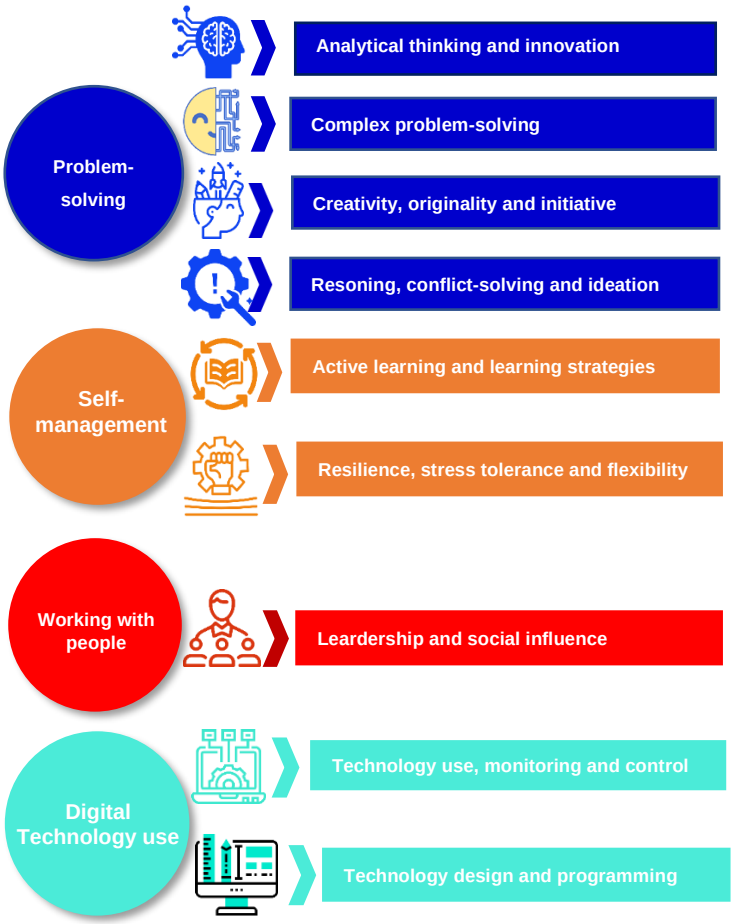


Figure 24. Four competitive skills associated with the top ten skills adopted from (Grzybowska & Anna, 2017; Kate Whiting, 2020).

6.2. Trend of required skills by sectors

Employee adaptability is the meta-skill that will help the employees to handle digital transformation such as Industry 4.0. In Table 2, the representation from SMEs responded to the survey that on average there are 372.6 staff in total with the 95% confidence interval of (96.3, 648.9) and an average of male staff is 193.8 with the interval (58.4, 329.3).

Table 2. Average total staff in the enterprises

Overview of Staff	n	Mean	[95% CI]
Total Staff	100	372.6	96.3 648.9
Male	99	193.8	58.4 329.3

Industrial advancement and co-creation of value are promoted by young people who have acquired advanced skills at educational institutions or companies. For these reasons, it is imperative to provide training to young talent and next generation leaders in industry research for performance advance technology in industry 4.0. This will lead to a higher capacity for new R&D project and improve employability in a sustainable way by providing access to better paid job (Ras et al., 2017).

Table 3. Average number of staff education levels

Education Level	n	Mean	[95% CI]
No Education	100	94.2	18.4 169.9
TVET	100	16.8	8.6 25.0
Bachelors	100	216.1	22.5 409.7
Masters	100	24.9	-3.6 53.3
PhD	100	5.7	-4.4 15.9

Table 3 indicates the overall understanding on the average education level among employees working in an enterprise. In an average of 94.2 (18.4, 169.9) are seen no formal education among employees working in the enterprise, 16.8 (8.5, 25.0) are staff with technical and vocational education and training (TVET), 216.13 (22.5, 409.7) are staff with the education of *bachelors'* degree, 24.89 (-3.6, 53.3) complete their advance study and research with *masters' degree*, and 5.77 (-4.3, 15.9) successfully complete their study and research with PhD. It observed that with less of PhD company could not enrich innovation or R&D.

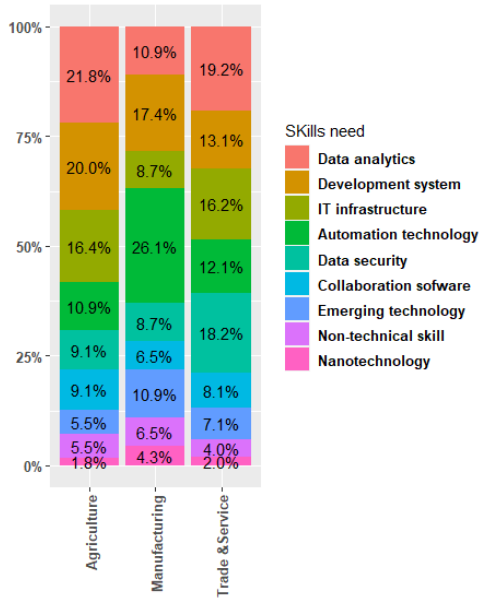


Figure 25. The area of skill that enterprises need in the next three to five years

Which area of skill that enterprises need in the next three to five years? As presented in **Figure 25**, in the agriculture sector, there are some specific skills will be highly needed such as data analysis accounting for approximately 21.8%, followed by development systems (20.0%), IT infrastructure (16.4%), automation technology (10.9%), data security and collaboration software (9.1%), and the rest are emerging technologies, non-technical skill and nanotechnology with 5.5%, 5.5% and 1.8% respectively. In manufacturing, the prioritized technology that is commonly needed in the future is automation technology (26.1%), development system (17.4%), data analysis (10.9%) and infrastructure (8.7%), and the rest are non-technical skill and collaboration software (6.5%), and nanotechnology (4.3%). In addition, in trade and service sector, the skill that needs to be prepared for the future is not different from agriculture and manufacturing sectors. There are data analysis (19.2%), data security (18.2%), IT infrastructure (16.2%), development system (13.1%), automation technology (12.1%), and collaboration software (8.1%), emerging technology (7.1%), non-technical skill (4.0%) and nanotechnology (2.0%).

Currently, data analysis which also includes big data is a set of techniques focusing on gaining actionable to extract insights from a massive amount of information to make a smart decision (Duan & Da Xu, 2021). As a result, **Figure 25** illustrates that the data analysts are in high demand, and this trend is expected to continue in the next three to five years. IT infrastructure and development systems are critical for organizations to operate efficiently and effectively. As technology evolves and becomes more complex, there is a growing demand for professionals who can design, develop, and maintain IT infrastructure and development systems. Another high demand, automation technology, is rapidly transforming the way organizations operate, reducing costs and improving efficiency. Professionals who can design and implement automation

solutions are in critical demand of enterprise development ecosystem. As well as data security is essential since it can help organizations store more sensitive information than ever before, including customer data and financial information and prevent the organizations from the increasing number of cyber-attacks and data breaches. Collaboration software is becoming increasingly important as remote work becomes more common. As a result, there is a growing need for professionals who can design and implement collaboration tools and platforms. Emerging technologies such as AI, blockchain, IoT, and other supporting technologies serve as backbones for upgrading enterprise chains (Mithas et al., 2022; Okwu et al., 2022). As indicated in **Figure 25**, these skills have gained its popularity over the years and continued in high demand in the next three to five years. They are rapidly transforming industries and creating new opportunities. However, it requires at the same time other skills including communication, leadership, project management, critical thinking, reasoning, and understanding how to control advance technology to prevent terrible mistakes that may repeatedly happened mindlessly. These people will utilize their profession to control the computer systems and robots that are automatedly operated by AI in conditions of distribution, diversity, and uncertainty (Cellary, 2019). Nanotechnology is a rapidly growing field with applications in various industries, including aerospace, automobile, construction, manufacturing, food processing and packaging, medicine, electronics, energy, and forensic science. In the industry 4.0, the application of nanotechnology in energy storage, lighting and photovoltaics are extensively needed to support the popularly growing application areas. These are the key skill sets that leading to a future in advanced technology utilization. For instance, medical high-technology of nano-technology applications will continue to advance for a new battery materials (AbdelHamid et al., 2022) and DNA nanotechnology (Huang et al., 2021; F. Li et al., 2021).

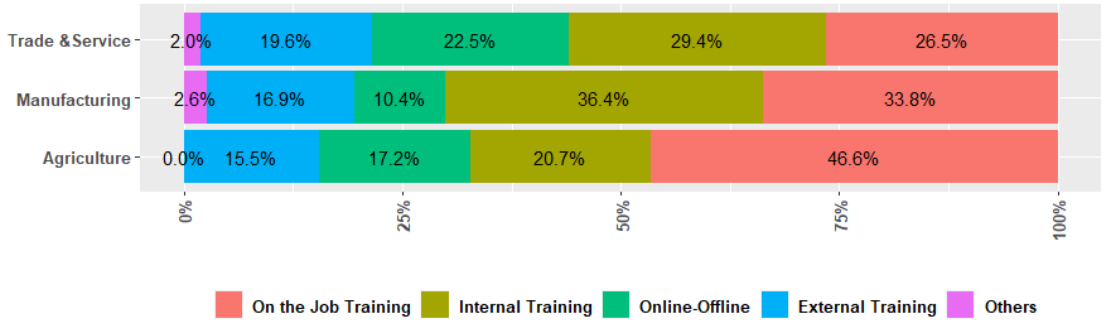


Figure 26. SMEs capacity building program

It will also have a positive effect on well-being, enabling more (especially young and old) people to keep their jobs through up-skilling and reskill to maintain job performance requirements to increase (Bongomin et al., 2020; L. Li, 2022). Due to the new skillset, employees at all levels from operators to engineers and administrators will increasingly include designing, maintaining, and supervising intelligent machines that help perform tasks. The job of the future will require specific

skills that are not yet fully addressed by the education and training system. Enterprise could apply for an active role in the form of training to upskill and reskill employees. In **Figure 26**, there are several common forms of capacity building that SMEs provide to employees or staff. In the agriculture sector, the on-job training share (46.5%) followed by internal training (20.6%), online-offline training (17.2%), and external training (15.5%). In manufacturing, capacity building provides mostly internal training (36.3%), on-job training (33.7%), external training (16.8%), online-offline (10.3%), and others (2.6%). In the trade and service sector, internal training (29.4%), on-job training (26.4%), online-offline (22.5%), external training (19.6%), and others (1.9%).

In overall, enterprises capacity building program often prioritize on-the-job training, internal training, and online-offline, which can be valuable for skill development within the organization. However, promoting external training, it is critically as an ecosystem of both vertical/horizontal technology transfer model, particularly in the initial stage of technology advancement in Cambodia. The current context suggested that horizontal technology transfer model of collaboration between business to business is necessary for short- and medium-term development of enterprises, while vertical technology transfer model in form of universities to private sectors through research and development could be embedded based on available resources is also needed for long-term development.

7. Suggestion for transformation

7.1. Priority for adoption and transfer

Mobile-first strategy: Mobile devices have a high penetration rate in Cambodia, and this trend is expected to continue. Adoption of mobile-first strategy that focuses on delivering a seamless experience to customers and employees on their mobile devices is recommended. This includes developing mobile apps for CRM, HRM, accounting, and other business functions.

Cloud-based solutions: Because of its low price and adaptability, cloud computing has becoming increasingly popular in Cambodia. Cloud-based solutions are necessary for various applications such as accounting, HRM, CRM, and other enterprise applications. Cloud solutions can provide greater scalability, security, and accessibility to businesses in Cambodia.

IoT and sensor technology: This technology is becoming trendy in Cambodia due to the need for better management of resources such as water, energy, and agriculture. Adoption and transfer of IoT and sensor technology is indispensable for real-time monitoring, data collection, and analysis. For example, smart sensors can be used in agriculture to monitor soil moisture levels and help farmers make informed decisions about irrigation.

Radio-frequency identification technology: RFID is an emerging technology that can improve inventory management, supply chain tracking, and customer experience. Adoption and Transfer of RFID technology is highly recommended for firms to track inventory, monitor supply chain logistics, and improve customer experience by providing real-time information on product availability.

Data analytics: Adoption and Transfer of data analytics is necessary among firms to gain insights into customer behavior, market trends, and business operations. Data analytics can help businesses make informed decisions, improve efficiency, and gain a competitive advantage in the market.

Cybersecurity: With the increasing use of technology, cybersecurity is becoming a critical concern in Cambodia. Therefore, Investment in adoption and transfer of technology with robust cybersecurity measures is critical to protect data and assets from cyber threats. This can include investing in security software, conducting regular security audits, and providing cybersecurity training to employees.

Machine-to-Machine: the adoption of M2M technology is needed to consider as a crucial step towards upgrading to Industry 4.0. M2M technology will enable automation, data integration, and advanced connectivity, empowering Cambodian industries to enhance efficiency, competitiveness, and innovation in the rapidly evolving global landscape.

Per national priority sectors set by the government, enterprises are highly encouraged to embrace technologies mentioned above to serve national goal. The eight priority sectors set as national agenda in priority sectors including agro-processing, energy, mechanic and electrical industries, cloud-base services, digital enhanced health, education, electricity and water, and carbon neutrality are for enterprises to materialize the technologies. On the other hand, the horizontal model of technology transfer is recommended to be frontier of investment, while investment on vertical technology transfer is slowly integrated to embrace resilience and long-term development.

7.2. Maturity and ways forward for firms

For agriculture, cloud computing, robotics, blockchain, and weather tracking should be encouraged to adopt by enterprises, as these can significantly improve the efficiency and productivity of agricultural processes. Specifically, for enterprises operating between 3 to 5 years, efforts are to encourage for adoption and transfer of cloud technology, while for those operating less than 2 years, steps must be taken to help them overcome the uncertainties and challenges in adopting new technologies like robotics, blockchain, and cloud.

For manufacturing, enterprises that have been operated less than 5 years, special attention for adoption and transfer is for some needed technologies including M2M communication, Real time location systems and AR & VR, as they lead to improvements such as cost-effectiveness, reduced human error, and increased traceability.

For trade and service enterprises, it is recommended that potential benefits from adoption and transfer is to quickly adapt to emerging technologies and re-evaluate their return-on-investment calculations. While it is true that the ROI for some technologies may initially appear low, it is important to consider the potential long-term benefits, such as increased efficiency, better customer service, and ultimately higher profits. Enterprises can also consider strategies to minimize the initial investment, such as selecting cloud-based solutions that do not require significant physical infrastructure or hiring temporary contractors with tech experts. It is essential that enterprises are to update on emerging technologies and their potential benefits. Form of participation can be necessary, such as attending trade shows, conferences, and webinars, communicating with SMEs and SMEs associations. Enterprises in the trade and service sector can position themselves for long-term growth and success.

Enterprises in the three investigated fields are urged as a whole to establish in-house platforms in the forms of training and education programs that reskill and/or reskill the workforce with the necessary knowledge and technologies with innovative-oriented approaches. Overall recommendation to the three sectors studied, it is suggested that enterprises are encouraged to have inhouse platforms in the forms of training and educational programs that reskill and/or reskill the workforce with the necessary knowledge and technologies with innovative-oriented approaches.

Per mandate of MISTI, particularly GDSTI, it is highly private sector investment in SMEs cluster, STI parks and/or High-tech Park. This investment is critical to allow Cambodia to hardness faster technological advancement for serving industrial development. At the same, it is more efficient to address innovative purposes, while considering emerging trading regulatory framework such as environmental social governance set by market.

7.3. Overcoming challenges

Having platforms of sharing knowledge and skill is indispensable for enterprises. The platform could be named as “Technology Platforms” allowing stakeholders exchanges knowledge or technologies. The platforms must be with innovation-driven mission allowing stakeholders from academia, government, and private sectors to share common interests and expertise. It is critical to have the improvement of collaboration among technology brokers, technology creator or owner, and technology users.

Investment in R&D is a must for the resilient development of enterprises. Knowledge and innovative technologies made by the local responses correctly to local demand. It is recommended that investment for research & development from public sector, private sector, and joint scheme must be in place. Without significant investment in R&D, there is a limited pool of new technologies that can be transferred to the sector, which hinders its ability to modernize and improve.

7.4. Human capital for industrial innovation

Enterprises demand in the future for the right mix of fundamental, soft, and technical skill, especially digital and business-specific competence. Cambodia's enterprises require a more competent workforces that are adaptable enough to new technical advancement. Knowledge capacity and available number of experts are paramount important to cope with the demand of three sectors. The formal educational system needs a comprehensive strategy to meet the needs of the private sector. It is to reconfirm the need to alleviate the skill gap and skill mismatch for STEM major. Enterprises demand heavily some important technologies including data analytics, automation technology, system development, IT infrastructure, to name some. While technology made by local remains limited, the enterprises are highly recommended for having in-house training in collaboration with matured or strong corporates for transferring of technology to employees.

On the other hand, joint curriculum development between the private sectors and educational institutions like universities and technical and vocation training schools is necessary to meet the current demand. Simultaneously, it is crucial to design curriculums beginning with early childhood education that foster an entrepreneurial spirit in the brains of future generations. Likewise, the investment of quality researchers in public or private sector to produce innovative knowledge for local demand is a must in the development agenda.

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APPENDIX I

The study's use of technical terms is in accordance with the definition that is provided below.

- **Technology Transfer:** aims to promote the transfer of technology, knowledge, know-how, technical skills, and innovation from institution to institution or from legal entity to legal entity to underpin the technological evolution in industry and other sectors in the Kingdom of Cambodia (Technology Transfer law).
- **Material transfer:** transfer of material components or equipment which your company can't produce.
- **Design transfer:** provide basic information, data, designs, and the know-how to your company from manufacturing previously designed products.
- **Capacity transfer:** provide the know-how and software to innovate and adapt existing technology or products, and ultimately design new products.
- **Staff capacity building:** provide a capacity building program to staff within the gap of monthly and/or yearly.
- **On-the-job training:** provide new employees with learning applicable skills for their role while in the workplace. It's a practical training method focused on a hands-on approach in a live or simulated training environment, typically under the guidance of a supervisor or mentor.
- **Internal training:** refers to a training program that's conducted within an organization using its own expertise, manpower, and resources. It typically focuses on the development and improvement of employees' skills and knowledge relevant to their current roles and responsibilities.
- **External training:** is conducted by experts or influencers from outside of your company. They may be someone your company already has a relationship with – such as a supplier – who has been brought in to give more information on a product or feature, or an industry expert who can share the latest trends to help teams stay ahead of competitors.
- **Online-offline training:** you can study anytime and anywhere, even in the comfort of your own home. Offline learning requires you to travel to a classroom location and arrive on time and it allows you to interact with fellow students in a real-life environment.
- **Non-technical skills:** refer to systems thinking and process understanding.
- **Access to market:** refer to the process of matching facilitation with technology suppliers.
- **Access to emerging:** refer to the accessing the information of latest technology or technology scouting, and latest R&D.

- **Licensing:** It is a contractual arrangement in which the licenser's patents, copyrights, trade secrets, industrial design or other intellectual property are provided for the use of technology to the licensee under which only a license holder can use the technology. The specific code and identity of the system through which they can be used on the authorized system are only by the authorized user of that system.
- **Franchising:** It is quite like licensing where the organization set up franchises and transfers technology to the franchisee. The franchisee operates on behalf of the organization under the company have direct control.
- **Management Contract:** The technology is transferred under certain terms and conditions or by establishing projects for hosts and training personnel to operate it and transfer the control to hosts.
- **Joint venture:** It is a business entity created by two or more parties pooling their resources with the objective of implementing a common business purpose. one party may contribute with technology or know-how and the other party may provide investment.
- **Turnkey Agreement:** a country buys a complete project from an outside source and the project is designed, constructed, and equipped with all facilities in return for a fee.
- **Foreign Direct Investment:** Through this technique, the organization transfers its technology to the target nation through its subsidiary.
- **Buy-Back Contract:** It is a form of agreement between stakeholders from developing countries and large foreign companies, wherein a foreign company supplies technology equipment in exchange for profits derived from the sale of raw materials or goods produced.
- Assignments of intellectual property rights: Assignment of IP rights has a definitive effect, like selling tangible assets, thus the former owner will be permanently divested of the ownership.
- Machinery Supply Contract for manufacturing: It refers to the transfer of technology to the user and getting the product, machinery and spare parts manufactured through a partner from the host nation.

APPENDIX II

1. Sample size

1.1. Confidence interval for a proportion

An approximate confidence interval for p based on a normal distribution is given by

$$\hat{p} \pm z_{\frac{\alpha}{2}} \sqrt{\widehat{Var}(\hat{p})} \qquad (1)$$

Where

$\epsilon = z_{\frac{\alpha}{2}} \sqrt{\widehat{\text{var}}(\hat{p})}$

$\widehat{\text{var}}(\hat{p}) = \left(\frac{N-n}{N}\right)\left(\frac{\hat{p}(1-\hat{p})}{n-1}\right)$ is an unbiased estimator of the variance,

$\hat{p} = \frac{1}{n}\sum_{i=1}^{n} y_i$ is the proportion in the sample

$z_{1-\frac{\alpha}{2}}$ is the value of the normal standard coordination for a desired level of confidence $1-\alpha$.

The normal approximation on which this interval is based improve the larger the sample size and the closer p is to 0.5.

1.2. Sample size for estimating a proportion

The sample size necessary for estimating a population proportion p of a finite population with $(1-\alpha)100\%$ confidence and error no longer that ϵ

$$n = \frac{m}{1 + \frac{m-1}{n}} \qquad (2)$$

where, $m = (z_{\frac{\alpha}{2}}^2 \, \hat{p}\,(1-\hat{p}))/\epsilon^2$,

Re-write the formula (2),

$$n = \left[\frac{1}{N} + \frac{N-1}{N}\frac{1}{PQ}\left(\frac{k}{z_{1-\frac{\alpha}{2}}}\right)^2\right]^{-1} \qquad (3)$$

Where N is the population size, p population proportion, $Q = 1-P$, k is desire level of precision, $z_{1-\frac{\alpha}{2}}$ is the value of the normal standard coordinate for a desired level of confidence $1-\alpha$.

Table 4. Sample size requiree with 5.0% and 7.5% of precision, p = 0.5 of proportion, and 90.0% confidence interval of infinite population.

$\hat{p} = 0.5$	$\epsilon = 0.05$	$\epsilon = 0.075$
N very large or Inf	271	121
N= 10,000,000	271	121
N= 1,000,000	271	121
N= 100,000	270	121
N= 10,000	264	119
N= 1,000	213	108

Although a 7.5% precision would be most desirable in this study. Hence, the study will consider a target sample size around 100 to be achieved in the survey study.

1.3. Logistics regression (Odd ratio)

In order to investigate the determinants of adoption and transfer of technologies by SMEs/Industry we use count data regression analysis. The dependent variable is the number of technologies adoption and technologies transfer by SMEs/Industry by the time of survey, which is the realization of a nonnegative integer-valued random variable. With this regression method, the dependent variable takes value $0 \leq p \leq 1$ where the probability $\Pr(Z = 1) = p$ and $\Pr(Z = 0) = 1 - p$. That is Z is a Bernoulli distributed random variable having p.m.f

$$\Pr(Z = z) = \begin{cases} p^z(1-p)^{1-z}, z = 0,1 \\ 0, \quad \text{Otherwise} \end{cases} \tag{4}$$

If there are n such random variable $Z_1, \dots, Z_n$ which are independent with $\Pr(Z_j = 1) = p_i$, then their join probability is

$$\Pr(Y = y) = f(y; n, p) = \begin{cases} \binom{n}{y} p^y (1-p)^{n-y} \;\; y = 0, 1, 2, \dots, n_i \; ; 0 \leq p \leq 1 \\ 0 \text{ Otherwise} \end{cases} \tag{5}$$

Where n_i is the number of trials in group i and $E(Y_i) = n_i p_i, Var(Y_i) = n_i p_i (1 - p_i)$.

The associate log-likelihood function can be defined as

$$l(p) = \sum_{i=1}^{n} \left\{ y_i \log\left(\frac{p_i}{1-p_i}\right) + m_i \log(1-p) + \log\binom{m_i}{y_i} \right\} \tag{6}$$

The data of the form of y_i success out of $m_i, i = 1, 2, \dots, n$ are available, the corresponding estimate success probabilities, $p_i = \frac{y_i}{m_i}$ is to be modelled as a linear combination of k exploratory variables $x_{1i}, x_{2i}, \dots, x_{ki}$

$$\hat{\eta}_i = \log\left(\frac{\hat{p}}{1-\hat{p}}\right) = \boldsymbol{X_i^T} \; \widehat{\boldsymbol{\beta}}, \tag{7}$$

Giving the corresponding fitted values; p_i defined as

$$\hat{p} = \frac{\exp(\hat{\eta}_i)}{1+\exp(\hat{\eta}_i)} = \frac{\exp(\boldsymbol{X_i^T}\,\widehat{\boldsymbol{\beta}})}{1+\exp(\boldsymbol{X_i^T}\,\widehat{\boldsymbol{\beta}})}$$

And $\mu_i = \boldsymbol{E}(Y_i) = m_i p_i$, therefore the fitted values of μ_i is $\hat{\mu}_i = \frac{m_i \exp(\hat{\eta}_i)}{1+\exp(\hat{\eta}_i)}$

When two set of binary data are to be compared, a relative measure of the odd of success in one set relative to that in the other is odd ratio, where the estimate of the population odd ratio, denote $\widehat{OR}$, is

$$OR = \frac{\frac{p_1}{1-p_1}}{\frac{p_2}{1-p_2}}$$

The approximate $100(1-\alpha)\%$ confidence interval for $\log(\mathrm{OR})$ is

$$\log(\widehat{OR}) \pm Z_{\frac{\alpha}{2}} \times S_{\log(\widehat{OR})}$$

Where $S_{\log(\widehat{OR})} = \sqrt{\frac{1}{a}+\frac{1}{b}+\frac{1}{c}+\frac{1}{d}}$, is the approximate standard error of the log odd ratio.

1.4. The Chi-Square test of independence $(\boldsymbol{\chi^2})$

$$\chi^2 = \sum_{i=1}^{2}\sum_{j=1}^{2} \frac{(O_{ij}-E_{ij})^2}{E_{ij}}$$

Where O_{ij} observed frequencies of i^{th} row and j^{th} column

$E_{ij} = \frac{(i^{th}\ row\ total)\times(j^{th}\ column\ total)}{n}$ expected frequencies of i^{th} row and j^{th} column.

1.5. Crammers' V

Cramér's V is computed by taking the square root of the chi-squared statistic divided by the sample size and the minimum dimension minus 1

$$V = \sqrt{\frac{\chi^2}{n} \times \frac{1}{(k-1, r-1)}}$$

where, χ^2 is derived from Pearson's chi-square test, n is the grand total of observations, k being the number of columns, r being the number of rows.


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