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Technology Transfer Strategies for Patents Across Offices in Academic Institutions Across the USA, India, and Kenya

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ABSTRACT

The global market and its drive for competition for the creation and operation of technology transfer offices that established for me between India and industry. It fills an important role of carefully filtering through ideas that can be ass produced for commercial viability. It also fills in the role for saving financial and regulatory collapses that could potentially lead to risks; hence risk mitigation is an indirect role for these offices. Though the idea of relatively new but has found traction at an accelerating pace. The objective of this study is to find out common successful strategies from different technology transfer offices (TTOs)in three countries from i.e. USA, India and Kenya. Their choice reflects a case where extreme ends of the spectrum will be evaluated (USA and Kenya) and India in the middle with some infrastructure that remains in place while a lot of work remains pending. The paper critically identified the diverse strategies implemented by these TTOs, aiming to discern the variations in their approaches and uncover the elements that prove effective. The research covering above jurisdictions also have a focus on TTOs from academic Institutions. It is important to understand the public funded academic Institutions from selected jurisdictions, as the success strategies would be a key learning factor for TTOs from various other academic institutions.

Keywords: *Strategies, Technology Transfer, Academic Institution, Licensing, Industry-Academia Partnership, University Technology Transfer.*

Introduction

The field of technology transfer concerns itself with establishing links between the academic oriented research work done in academic institutions and their conversion to industry supported patents and generate a reproducibility factor such that the intellectual property rights (IPRs) generated are utilized, eventually converted into manufacturable products and provide potential for commercialisation. The concept gained traction in the western countries from 80's and 90's [1], [2], [3], [4]. The task of a Technology transfer office (TTO)is to increase this reproducibility factor by transferring academic technology to an appropriate industry partner erstwhile managing licensing and other intermediary processing. However, the current situation is that there are very few academic institutions, especially in developing and underdeveloped countries that provide such facilities extensively[5]. Both ends of the chain are necessary, since it is the academia that gives ideas and undertakes trial and testing of these ideas, whereas the industry has played the role of mass producing the product such that it is a consumable that can be made to generate revenue. The finances, logistics, manpower, certifications, and paperwork are handled by industry. This is only an ideal scenario, and there is a significant dearth of academicians having

a detailed understanding of these procedures[6]. Several reasons have been cited for this as back as 2005, where [7]reported non-responsive or lengthy governmental/agency interactions, academicians not feeling the need for such a discourse as necessary, and the general lack of awareness of the details of TTO. Academics and scientists usually stay and working in close knit communities that collaborate among each other to produce papers andpatents. Further, a large portfolio of patents would be necessary for an institute to achieve a significant return on investment for each patent to materialize into positive returns. Some studies such as [8]pointed out a subtle balance that needs to be struck, where the number of patents must also be sufficient large for some of them to become profitable, but also prevent filing of redundant patents that will not contribute and ultimately affect the reproducibility factor. Studies such as [9], [10], [11] have elaborated on the ways in which the reproducibility factor can be kept at an optimum, using well-funded pathways and refer to them as 'enablers' or 'barriers' depending on the term.

The issues underlying do not just lie with lack of information among academics, but also the presence of appropriate funding among institutions. In USA, the TTO generally takes up 0.3% of the total annual expenditure, whereas for India and Kenya, this number is not available. To note, the absence of this number itself speaks of the lack of awareness of such practices in these countries. The stint of quick commercialisation of technologies and such practices are prevalent in countries such as USA, Europe and even China[12], [13].

Some of the older studies in this area include [14] which analysed the industry-academia relationship in UK and USA in the 1960s and found that university culture was heavily intertwined with the local community and social background of the place. This helped them in maintaining a connection with the local market and its industrial needs, but a larger cross-country association was missing. Comparing to nearly half a century later, USA still supports the same ideology[15], and colleges are well connected with local communities, but UK has reported a rather decline in this. While academic institutions have increased associations with large scale businesses and major industrial firms now have regular interactions with them, local scale technology transfer has reduced by as much as 30%. This has recently been attempted to change, with Colleges of Technology, such as the University of Salford and Aston University have taken up measures to intensify knowledge and technology transfer. One recent study from India, [16]found that the needs of industry and academia are often misaligned in India, and that leads to increased miscommunication between the two. In terms of revenue generation, 50% of the universities/institutes generated revenue of 50 Lakh to 1 Crore INR. Only 13% of the universities generated a revenue of more than 1 Crore INR through technology transfer activities. Lastly, 37% of private organizations had transferred approximately 10 technologies. Also, there are fewer cases where an innovation is socially relevant, and innovation rarely means a novel introduction of a technology or product. The study mentioned that Indian academia needs stronger learning of industry-oriented approaches to problem solving and changes be made to academic curriculum and teaching methodologies as well. Another study by [17] evaluates the intellectual property (IP) policy and innovation practices of higher education institutions (HEIs) in India. It also aims to understand the impact of the national intellectual property rights (IPR) policy at the ground level and identifies the barriers that HEIs face in the generation of IP, its commercialization, and technology transfer. The results suggest that IP policies and innovation practices of HEIs in India are evolving and need to align with the global standard as envisaged in the national IPR policy. Finally, looking at some studies from Kenya [18] have surveyed the TTO landscape in Kenya, with focus on the energy sector, and related industries around Nairobi. They concluded that even recently, there has been any relation between academia and industry that was inspired through foreign grants, and technology transfer through oil and gas companies. Hence, even today the FDI is still a major source of technology diffusion. However, not all hope is lost and there have been ways where FDI and tech transfer has positively contributed to sustainable practices even among low income countries, as pointed out by an OIC study [19].

This article performs a comparative analysis of TTO and associated practices comparing between USA, India, and Kenya. These countries are chosen such that identification is done over for the full bandwidth of countries in world. USA represents a first world country where there is an inherent readiness towards acceptance of new technologies, followed by India that lies in the developing countries and finally with a developing country Kenya, with focus on identification of papers, available policy framework and strategies adopted by TTOs in academic Institutes of selected countries from three different continents i.e. USA, India and Kenya in a comparative manner, USA was chosen as it has the history of most progressive academic TTOs, while India as a developing country was chosen due to the recent trend of increased number of patent filings as the top 10 patent application filer, while Kenya was

chosen among the under developed countries due to its recent ranking of top three innovative economy from sub-Saharan Africa region.There are different mechanisms at place in each country as per local norms [20], and some even work semi-actively or passively in developing countries. These represent the extremes of the spectrum and shall serve as an effective guide for the identification. The systematic literature search determines the number of articles, reports published in this regard, by demographics and topic of research. The objective is to understand, through data, the factors that influence industry-academia interaction, technology transfer cost, ease of business, governmental support and grants.

Literature Review

The initial step focuses on constructing precise search strings that include relevant keywords capturing the essential ideas behind technology transfer. Controlled vocabulary terms and Boolean operators are meticulously utilized. Primary sources include reputable databases such as Scopus, IEEE Explore, and Web of Science. The search strings are designed to capture various facets of technology transfer, including strategies, academic institutions, industry-academia partnerships, incubation, deep tech entrepreneurship, innovation, licensing, and patents. A substantial volume of scholarly articles, conference papers, and reports is retrieved by querying these databases. The citations and references from these documents form the foundation for our literature review.

The second stage involves rigorous title screening. Each article's title is systematically reviewed to determine its alignment with our research focus. Articles related to customer churn, telecommunication, or unrelated topics are excluded. Only those directly pertinent to technology transfer remain under consideration. Following title screening, abstract evaluation is performed. Articles that survive the initial filter undergo a more detailed assessment. Abstracts are scrutinized for relevance to technology transfer implementation. Specific keywords, such as "churn prediction" and "churn prediction models," guide our selection. Any article lacking relevance to our research objectives is eliminated. Having assembled a substantial set of relevant articles, expert input is sought. An interdisciplinary team of researchers reviews the selected works. Their expertise allows for systematically categorizing articles based on common themes, methodologies, and research approaches. This bottom-up classification facilitates a holistic understanding of technology transfer dynamics.

While much of the analysis remains qualitative, the need for quantitative insights is recognized. Statistical charts and plots will complement the textual findings, providing a nuanced perspective on technology transfer trends. By combining qualitative and quantitative approaches, valuable knowledge is contributed to the field.

Research Methodology

The methods used to accomplish this study in a comparative manner from three different countries, the methodology includes the research based on secondary data.

Table 1: Search Strings used to Obtain Literature

Databases used	Google Scholar, Science Direct, Scopus, IEEE Explore, Web of Science
	(TITLE-ABS-KEY (technology AND transfer) OR TITLE-ABS-KEY (strategies) AND TITLE-ABS-KEY (academic AND institution) OR TITLE-ABS-KEY (industry-academia AND partnership) OR TITLE-ABS-KEY (university AND technology AND transfer) OR TITLE-ABS-KEY (incubation) OR TITLE-ABS-KEY (deeptech AND entrepreneu) OR TITLE-ABS-KEY (deeptech AND innovation) AND TITLE-ABS-KEY (licensing) OR TITLE-ABS-KEY (patents)) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "cp"))*
Search Strings	'technology' AND 'transfer' 'strategies' AND 'academic' AND 'institution' 'industry-academia' AND 'partnership' 'university' AND 'technology' AND 'transfer' 'incubation' 'deeptech' AND 'entrepreneur*' 'deeptech' AND 'innovation' 'licensing' 'patents'

Exclusion criteria	Papers that are not relevant to technology transfer. Papers that primarily focus on other aspects of academic institutions or partnerships unrelated to technology transfer. Papers that do not specifically address or investigate the strategies of technology transfer. Papers that solely discuss incubation or deep tech without a clear link to technology transfer.
Inclusion criteria	Papers in peer-reviewed journals or conference proceedings. Papers that specifically discuss or investigate technology transfer. Papers exploring technology transfer strategies within academic institutions, industry-academia partnerships, and universities. Papers that discuss the role of incubation, deep tech entrepreneurship, and innovation in technology transfer. Articles investigating the legal aspects of technology transfer, such as licensing and patents.

In the scope analysis, 1,138 articles were collected from 2000 to 2023. The literature, comprising journals and proceedings, was consolidated to define the scope of content used in the thesis. It was imperative that the problem statement be correctly defined, and the scope of improvement understood. Scholarly works were selected through commonly used databases, focusing on articles that discussed various aspects of technology transfer, including strategies, academic institutions, industry-academia partnerships, incubation, deep tech entrepreneurship, innovation, licensing, and patents. This comprehensive collection process included various methodologies and models pertinent to technology transfer, laying a robust foundation for the research.

Research metrics are extracted from the literature search in the form of metadata, serving as a foundational element for the study. From the 1,138 articles collected, metadata is gleaned to include subject areas, application domains, and authors' geographical distribution. The top 10 journals are identified, providing a focused view of the leading publications in the field. The number of publications per year is catalogued, offering insights into the research trend. Articles are categorized by domain specialization, authorship, territorial presence, institutional affiliation, and funding sponsorship. These metrics and visualizations are instrumental in identifying the core areas of technology transfer research and the field's evolution.

The literature explores a diverse range of subjects, reflecting the multidisciplinary nature of the field. Business and management account for 24.2% of the literature, while engineering accounts for 14.3%. Social Sciences represent 13%, and Computer Science, Medicine, and Biochemistry are also analysed for their contributions to technological advancements and transfer processes. Several journals stand out for their significant contributions to the field, such as the Journal of Technology Transfer, Research Policy, Nature Biotechnology, Industry and Higher Education, and Technovation. These journals contribute to a deeper understanding of the mechanisms and impacts of technology transfer across various sectors. The publication year is used to illustrate the temporal relevance of the research area, with 2023 having the highest number of publications, indicating a growing interest and expanding research in technology transfer strategies. The most prolific authors ranked from highest to lowest in terms of publications are Siegel, Link, Mowery, and Rocha. The United States emerges as the country with the most significant number of publications, followed by the United Kingdom and Italy. Research contributions from China, Germany, Canada, and Japan are also noted. Funding sponsors in the landscape of technology transfer research include the National Science Foundation (NSF) and the National Institutes of Health (NIH), which are pivotal in advancing scientific knowledge and facilitating technology transfer from academia to industry. A text-based co-occurrence map is constructed to visualize the relationships between frequently occurring keywords within the literature corpus, revealing patterns of keyword prevalence and association. Among the keywords, "university research," "ownership," "success," "scientific discovery," "control," and "R&D" are identified as particularly prominent. These terms are interconnected, indicating a strong relationship between academic research endeavours and the successful commercialization of scientific discoveries. In conclusion, the literature review on technology transfer provides a comprehensive analysis of various subject areas, sources, and trends in the field.

Compulsory licensing/Bayh Dole and the USA

Compulsory licensing is when a government allows someone else to produce a patented product or process without the consent of the patent owner or plans to use the patent-protected invention itself. It is one of the flexibilities in the field of patent protection included in the WTO's agreement on intellectual property — the TRIPS (Trade-Related Aspects of Intellectual Property Rights) Agreement [21]. Compulsory licence provisions in patent law are always hailed as an effective mechanism to curb the abuse of exclusive rights by the patent holder. This is also projected as a tool to facilitate access to patented products at affordable cost [22]. Bayh-Dole Act of 1980 forms the genesis of this change in the United States can be traced to the Bayh-Dole Act of 1980, which allowed U.S. universities to own inventions made during publicly-funded research, and gave U.S. universities great latitude in exercising and commercializing resulting (IP) rights [23]. However, the development of optimum models for operating academic TTOs are best understood as part of an ongoing process.

Emerging trends in India

In India, the differences between research undertaken in academia is felt separated from the demands of the industry. Even though the relevant supporting system for enhancing university-industry collaboration is in place, such as establishing technology transfer office (TTO) in the university, they hardly channelize the resources for socially useful innovation. It is important for Indian academia to undertake commercially viable research for the benefit of society. Innovation is the direct outcome of structured and planned scheme of work, referred to as research. The competition among the industry is exceedingly independent of the research undertaken by public funded or private research organizations and universities. The main advantage of universities are the faculty members and students who constantly enter the system, bringing fresh concepts, ideas that eventually leads to research and innovation. Finally, complexity of innovation (or otherwise), which requires a strong business acumen to navigate through industry collaborations were seen as a hindrance to successful commercialization and technology transfer.

Among the 25 universities/institutes that responded, four were central government institutions, seven were state private universities/institutions, five were deemed to be universities, and eight were private research organizations. 41% of respondents had 2–5 years of experience in IP/TT, 17% had more than 10 years of experience, and 21% had less than a year or more than 6–10 years of experience. 33% of the universities had less than ten invention disclosures, whereas 29% had more than 30 invention disclosures by the researchers in the past 5 years. 71% of the universities had entrepreneurship policy applicable to foster entrepreneurship among faculty members.

- 50% of the universities/institutes had above ten years of experience in IP.
- 50% of the universities/institutes had above 30 patents filed.
- 50% of the universities/institutes had above 30 collaborations.
- 75% of the universities/institutes had less than 5 technologies been transferred.
- 50% of the universities/institutes generated revenue of 50 L—1 Crore.
- 13% of the universities generated a revenue of more than INR 1 Crore through technology transfer activities.
- 37% of private organizations had approximately 10 technologies transferred.
- 37% of private organizations had less than 10 L and 37% universities/ institutes between 11 and 50 L

The Technology Transfer Infrastructure in Kenya

The role of foreign direct investment (FDI) on technology transfer and economic growth in Kenya, particularly in the energy sector in Nairobi from 2001 to 2014, highlighting the significant role of foreign firms in enhancing economic growth in the agriculture sector, especially in floriculture and horticulture. The study also mentions the benefits of FDI in the form of knowledge transfer, technology transfer in production and distribution, industrial upgrading, workforce experience, and the establishment of finance-related and trading networks. The various ways in which the transmission of ideas and technologies occur, including international trade, foreign technology payment, direct adoption of foreign technology, and acquisition of human capital. It emphasizes that FDI is considered a major conduit of technology diffusion. The publications include various theories addressing the influence of FDI on

economic growth, such as Marginal Efficiency of Investment (MEI) and Accelerator Theories, Keynesian Theory of Economics, and neoclassical theory. The study is guided by the Keynesian Theory of Economics, which suggests that international aid can be mutually profitable by channelling under-utilized resources in developed countries to developing countries. The study adopted a descriptive and inferential survey design, targeting 60 senior managers from Kenya Power and Kengen. The data was collected using questionnaires. The study established a relationship between FDI variables of infrastructure, technology diffusion, trade facilitation, knowledge management, and technology transfer and economic growth. The study found that the independent variables infrastructure, technology diffusion, trade facilitation, and knowledge management explain 67.1% of the change in economic growth. The study concludes that FDI may promote economic development by contributing to productivity growth and exports in the host countries. However, the exact nature of the relationship between FDI and the host economies varies between industries and countries. The characteristics of the host country's industry and policy environment are important determinants of the net benefits of FDI, which include industrial growth, improved technology, and infrastructure. Kenya's installed generation capacity as of the end of March 2015 was 2295 MW or 0.049 kW per capita (43 million).

The establishment of Technology and Innovation Support Centers (TISCs) by the World Intellectual Property Organization (WIPO) in 2009 to support innovations in least developed countries. The implementation of TISCs in Kenya is evaluated, revealing that only 604 patents are registered per year, with 167 from nationals. Among these, an average of 5 patents per year is issued to Kenyans and 209 to internationals. The paper suggests a positive correlation between the application of patents, trademarks, and industrial designs with the establishment of TISCs. However, only 3 out of 14 TISC centres are fully operational, with the remaining 11 centres citing financial constraints and non-committal administrations[18]. The paper concludes with a recommendation that TISCs be hosted by learning institutions, financed by the Kenyan government, and treated as businesses. The role of technology transfer in economic growth, particularly in Asian countries as well as highlights the role of innovators in the process of technology transfer and the establishment of TISCs by WIPO to facilitate this process. The related work section compares TISCs in Kenya with Technology and Innovation Centers (TICs) in the UK, which were established to translate scientific ideas and innovations into products. The TICs relied on existing knowledge in research centres and universities. The study employs a correlation research design to evaluate the relationship between registered innovations and the establishment of TISCs. Data trends and patterns were analysed, and questionnaires were administered to key informers including KIPI, all TISCs in Kenya, and selected innovators in Kenya[24]. The results reveal that from 2000 to 2019, Kenya registered 604 patents per year, with 167 from nationals and 436 from international applications. Only 3 TISC centres are fully operational, offering services to innovators. The remaining 11 centres are still in the planning stages[25].

A comparison between the countries

The article discusses the commercialization of publicly funded research, focusing on university autonomy as a key variable. It suggests that research commercialization incentives can be affected by a top-down implementation that disregards the needs and capabilities of universities. Studies have used secondary data and interviews to examine research commercialization in Latvia. The results suggest that by allowing greater flexibility and experimentation with funding, universities could develop an entrepreneurial culture and address other deficiencies to commercialize their research more successfully. The article [26] introduces the concept of improving innovation performance in the European Union (EU) member states, with a focus on Latvia. It discusses the "European Paradox" — the inability to transform the results of technological research and skills into innovations and competitive advantages. The article also mentions the Bayh-Dole Act in the USA, which significantly changed the way publicly funded research is commercialized and has inspired other countries to view commercialization of publicly funded research as a remedy for insufficient innovation performance. It discusses triple helix model proposed by Etzkowitz and Leydesdorff[27] which proposes a more enhanced role for universities in knowledge-based societies. The article also discusses the concept of the "entrepreneurial university" and the role of Technology Transfer Offices (TTOs) in increasing university-industry-government relations. The article uses a single-case case study approach, relying on secondary data such as publicly available documents, studies, reports, and statistical data. Semi-structured elite interviews with researchers and other university staff involved in commercialization of research, as well as selected experts, were used as additional data sources. The challenges in the implementation of policy instruments to support commercialization of research. It suggests that the

chosen approach fails mainly because of insufficient experience in collaboration and frequentness of collaborations, insufficient capacity to organize and manage the process, and insufficient motivation for involved parties to engage in and carry out the process. The article also suggests that experimentation could be a potential solution to these challenges. The article concludes that universities are increasingly pressured to play a more important socioeconomic role, particularly by commercializing their research. It suggests that the approach to facilitating research commercialization needs to be adjusted to meet domestic needs and consider different development stages and capacity of the actors.

- R&D personnel and researchers were 0.6% of the total labour force in Latvia in 2018, while in EU28, it was, on average, 1.4%.
- The share of innovative companies in Latvia is growing (30% of the total number of companies) as well as the percentage of companies implementing technological (product and process) innovations (70% of total and a 17% increase since 2012 –2014).
- Only a third of those companies were engaged in innovative activities in cooperation with other companies or organizations. The number of patents was listed as one of the main goals of the program (also giving a project a stronger possibility to be approved if it was targeted), technology transfer eventually took place mainly in the form of publications and presentations at events, and no licensing agreements were delivered.

While 177 projects were submitted (122 approved) in Phase I, only 35 were submitted and 27 approved in Phase II.

Table 2: Key insights between USA, India and Kenya

Country	Key Insights
USA	• More than 80% institutes have dedicated teams or extensive collaboration between academia and industry
	• Academically oriented institutes contribute to nearly 14% of innovations that go through tech transfer
	• Expenditure given to run and maintain such departments runs in order of 15-18 Billion $ annually since 2015 onwards
India	• 37% of private organizations had budgets below ₹10 lakh.
	• 17% of universities/institutions had budgets between ₹11 lakh and ₹1crore.
	• The average annual budget allocated for IP cells among institutions is ₹5 lakh.
Kenya	• East Africa received $7.8 million in FDI in 2015, a 2% decrease from 2014.
	• Kenya's FDI flows reached a record $1.4 million in 2015.

The current situation shows a varied trends not only in terms of funding available or spent, but also in terms of the implementation of a disciplined infrastructure with adequate management and manpower.

Table 3: Detailed comparison over technology transfer processes and key numerics

Comparison	USA	India	Kenya
No. of patents annually	>10,000	2000-3000	<1000
Nature of industries collaborating with academia	Varied sectors including energy, defence, construction, telecom	Defence, telecom, biomechanical and biomedical	Energy, agriculture
IPR conversion ratio to commercial products	>70-80%	30-40%	< 10%
Availability of skilled manpower	Available and in demand	In demand but scarce	Scarce
Govt initiatives for training and skill development	Training done as per regulations devised through Acts and Laws	Training done based on western models and lack of regulations as need of the hour	Training outsourced and application specific

Revenue generation from licensing or sale of inventions	Revenue is generated through sale of IPR upon approval to commercialisation Revenue figures in order of billion USD	Revenue generation is slow but clear upward trend in last decade Revenue figures in order of million USD annually	Revenue generation depends on the private contractors and funding from the investment and highly dependent on its returns.
Universities have dedicated TTO offices?	Yes	Mainly govt institutes, and emerging private players	No
Legal regulation	Evolutionary and adaptive	Gap between performance and objectives and dedicated to resolution	Gap existent and recognised but requires more initiative for resolution

Discussion & Suggestions

Given the understanding of how the spectrum has evolved between the three countries, it can be seen that there exists known problems that require a dedicated hand-holding for a finite period of time and can be sustained autonomously after that. India has seen development in the last decades regarding awareness about the importance of such TTOs and have seen a growing trend among major government and some private players as well. Kenya has taken steps with increasing awareness and development of TISCs which will shape the way forward with regards to IPR and technology transfer[24]. In order that the TISC's run effectively, the government will have to fund in for its objectives with WIPOover the next decade and should be supported with massive awareness and training programmes. The successful implementation also requires strict and timely assessment with quarterly auditing.

Conclusion

The key conclusions and recommendations for the current study are:

Developed countries have an existing infrastructure that has been carried forward from the cold war era management policies. Although they still find relevant, the developed countries such as USA have extensive manpower, funding as well as a functioning system for technology transfer that has a history of collaborating well with industry. Since many institutes and firms have a technological head start during the first half of 20th century, they have maintained the lead and kept the same offices running.

Counties that are in the developing sector such as India have enough industrial as well as academic base and require to make efficient connections between the two. Many institutes have already recognised the importance and have taken adequate steps but that is highly dependent on government initiatives. A lack of complete autonomy still affects India today. The positive side is that an increasing number of such initiatives are being taken by more private institutes and research institutes. The next decade is expected to see these efforts come to fruit.

At the final end of the spectrum, many countries that are either under-developed or in between a transition phase towards developing. The case of Kenya is seen as rising beacon from Africa where efforts to consolidate the technology transfer has been on the rise. Most of efforts have come from energy and natural resources and has encouraged the government to take steps such as WIPO and setting up bold initiatives through TISCs. These efforts are expected to come to fruition in the coming years.

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