

The Role of Technopreneurship and Innovation System for Commercializing Battery Technology: A Comparative Analysis in Indonesia

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Abstract

The battery technology innovations have been created for some applications, including electric vehicle and energy storage in Indonesia. Unfortunately, the study about technopreneurship for commercializing the innovations is a relatively unexplored field and studies the relationship between the innovation system and technopreneurship seen from commercialization's point of view are virtually nonexistent. This paper provided a study of a technopreneurship model that is suitable for a technological, based on comparative research, some innovation of battery technology products. The article highlights common challenges and barriers faced by inventors and R& D centers in developing technological entrepreneurship along with its benefits for them. This is a comparative study based on case studies. The cases are diligently selected to examine a framework of technopreneurship and innovation system approach. The analysis was conducted by referring to the technopreneurship and innovation system approach to understanding the process of innovation management at the relevant technology transfer offices (TTO) and how the technopreneurship model is applied. The paper provides an insight into how technology transfer offices (TTO) organize and manage innovation activities with the technopreneurship model and how the constraints of technology commercialization on battery technology innovations.

Keywords

battery technology, comparative analysis, innovation system, technopreneurship

1. Introduction

In the global electric vehicle competition, Indonesia will start a business developing electric vehicles from electric motorbikes and electric batteries. The government has set a target that Indonesia will be able to produce two million electric motors by 2025. This priority is in accordance with the needs of vehicles in the community. Based on data from the Indonesian Central Statistics Agency, the development of the number of motorcycles in Indonesia in 2017 reached 113 million vehicles, far above the car at 15 million vehicles. Therefore, it is important to create a good ecosystem for the development of electric vehicles, ranging from regulations that support the climate of electric

vehicles, electric vehicle research and innovation, the grand design of electric vehicle development to down streaming in the industrial world. The development of the electric vehicle industry must be comprehensive, not only the final product in the form of an electric motor, but also important components for electric vehicles. The leap taken by the government began with technological innovations in electric vehicle parts and batteries (BRIN, 2019). Thus, advancement in battery technology is an important national priority for research. To expedite the programme, several research agencies and universities have been facilitated to build new battery laboratories by the government (Kartini et al. 2014).

There are several battery technology innovations that have been created for electric vehicle applications in Indonesia. The development was carried out not only by academics, but also by the R&D centre, government institutions, and private company. The innovations differ in terms of the development phase, from the first phase namely discovery till it succeeds as a business. In 2009, the Indonesian Institute of Sciences (LIPI) developed lithium batteries made from solid ceramics that were more heat-resistant for use in future vehicles powered by electric fuel cells (LIPI, 2019). Then Universitas Sebelas Maret (UNS) had begun research to develop lithium batteries for national electric cars in 2012-2014 (UNS, 2018). Furthermore in 2014, Research and Development Centre of Forestry Engineering and Processing of Forest Products, the Ministry of Forestry conducted research on making carbon spheres from rubber cassava starch for secondary lithium batteries used in electric cars (Research, Development and Innovation Agency, 2014). In 2018, LIPI also developed lithium battery components in the form of carbon obtained from local materials such as coconut shell, tea powder, and biomass (LIPI, 2018). In addition, there has also been an idea of the potential innovation of batteries from burning peatlands in Indonesia (Koran Pelita, 2020). Furthermore, Institut Sepuluh Nopember (ITS) is researching the potential of sodium as a substitute for lithium for electric vehicle batteries. Universitas Katolik Parahyangan (Unpar) also conducted this research by proposing local biomass waste, for example the skin of salak pondoh as an anode material for the sodium battery system (Katadata, 2019; Universitas Katolik Parahyangan, 2018). ITS has also developed an electric motor named Gesits since 2007, which is equipped with lithium batteries (ITS, 2017).

The success or failure of battery technology on the market is determined by using the four basic features that form creativity, innovation and competitiveness worldwide: (1) the collaboration and cooperation between governments, businesses, research laboratory and other specialist organizations, universities and small and medium-sized enterprise support service (SMEs), (2) the power of battery technology, (3) the efficiency which can be achieved in production and trade by management and organizational structures, and (4) the international agreements, rules and regulations. For a company it is impossible to make a technological breakthrough or innovation or to develop something new unless the new technology is used to make the business more competitive by raising profits, decreasing costs and similar changes in its economic results (Carayannis et al, 2015).

However, not all technological innovations can be present in the market. There are many untold innovations that never came out, and other probably revolutionary concepts fall into the so-called technical "valley of death" because of the difference between scientific science and industrial marketing. It is a lost opportunity for the company's economic and social growth and profitability. Thus, an improvement is needed by presenting technopreneurship and innovation system in battery technology innovation management, which will be studied in this paper. This paper highlights common challenges and barriers faced by inventors and R&D centres in developing technological entrepreneurship along with its benefits for them.

There are several previous researches studying about technopreneurship and innovation system. Selvarani and Venusamy (2015) studied technopreneurship in small and medium industry. Khin et al (2010) presented qualitative findings related to product innovation, ICT (info- and communication technology) approaches and tools for Malaysia's software sector technology. Theinsathid et al. (2009) demonstrated the complexities and difficulties of the start-up process to achieve practical outcomes. Klinton et al (2012) have developed an artificial neural network decision support framework for product innovation management. Oukil (2009) has discussed barriers to innovation and proposed some feasible solutions in the countries in northern Africa in question. Walker (2012) explored the cycle of technopreneurship in university spin-offs of academic entrepreneurs. The organizational culture of public organizations seeking innovative policies were proposed as an alternative to Suwant tothat et al (2015). Social entrepreneurship as an agricultural-innovation tool is suggested by Ellis et al (2012). In a university Technology Transfer Center, Rampersad et al. (2012) examined the usage in the management of innovation. Uriona et al (2009) presented a case study in small high-tech enterprises on innovation management. This article offers an overview of

how to deal with relevant problems related to innovation in battery technology using a productive market activity process (technopreneurship) to boost collective prosperity in the area of technology-based economic development.

2. A comparative study approaches

This is a comparative study based on case studies. The cases are diligently selected to examine a framework of technopreneurship and innovation system approach. The analysis was conducted by referring to the technopreneurship and innovation system approach to understanding the process of innovation management and how the technopreneurship model is applied. In this section, we elaborate the fundamental theory of innovation as management process, innovation process, and technopreneurship.

2.1. Innovation as a Management Process

Innovation management is a very collaborative process. It is a consequence of a continuous transfer of information between different parties, where every member of the team may play a leading role in the final outcome (Cooke et al. 1998). Innovation seems to be successful for the short term several times but does not seem to be so successful in the long term. The key factors are also the optimistic aspirations for future technical progress and the lack of an insight into unforeseen influences. A second point is that scientific or technological problems are the basic barriers in just a few cases. Organizational, financial and operational problems are typically hampered.

Management of creativity is difficult and dangerous. Among other issues, a failure study by businesses reveals that a large number of creative firms have not converted their technical innovation into successful business. Thus the challenge is not only to build creativity, but also to manage it properly to generate profit within the business. As it is clear that an organization's position in innovation management is a mechanism that should be structured and used to achieve a sound organization (Carayannis et al 2015).

2.2. Innovation Systems

The systems of innovation are seen as open, dynamic and social (Lundvall, 1992), which implies that innovations are created by social interaction between economic actors. This indicates they are devices communicating with their surroundings. In order, according to Carayannis and Campbell (2009), one should clearly demonstrate that a system model should co-exist with many other notions, such as innovation networks and information clusters, to understand the value of systems (and system theory). Interaction, synchronization, complementarity and enhancement are the main areas of networks' focus. For example, networks can be regarded as an internal structure which unifies and determines a cluster. Strategies to innovation processes are based on systemic approaches that demonstrate that markets do not develop or function outside of their laws and institutions. The aim of an innovation program is to develop, disseminate and leverage innovation.

2.3. Technological Entrepreneurship (Technopreneurship)

A hidden idea that is fundamental to many core problems is techno-preneurship. Various literatures describe, by using the term "technology-based businesspeople" (Florida and Kenney, 1988; Dahlstrand, 1999; Renko, Autio and Tontti, 2002; Oakey, 2003; Kakati, 2003), "technology-based entrepreneurs" or even "high-tech new ventures."

Technology-oriented entrepreneurs are the process and development of a new technical-involving enterprise, which uses technological inventions by "technopreneurs." Techno-prenovation is the process of investing in a project which collects and activates professionals with various assets that relate to the promotion of scientific and technological knowledge in order to build and gain value for a given company and also plays an active role in fostering this concept in the social context where the entrepreneur operates. Techno-preneurship aims to market inventions created by academic scientists through patenting, licensing, startup and collaborations between university and industry (Grimaldi et al., 2011).

The cycle of technological development is primarily concerned with technical developments in which technology can be used by businesses to create, manufacture and provide their goods and services as a system of technically and practical knowledge and abilities, so that it can be defined and embedded in personnel, facilities, equipment and physical procedures and pr Technopreneurial operation is creative application, individually or by a group of individuals, of techniques and expertise that generates and manages an undertaking and takes financial risk for its intent and outlook. In this way, the engineers have strong technical qualifications but also have no business and strategic thinking skills (Prodan, 2007).

2.4. Literature review

The process of technology development according to Parker and Mainelli (2001) is illustrated in Figure 1. Figure 1 provides the first marketing effect when scientific research technology is effectively approved. The second step occurs when a product development process in the business updates or adds technology to a product such that it can continue to be used in production or consumption. The marketing of research results is critical and is an integral part of the technology marketing cycle. Siegel (1995) describes technology marketing in general as "moving technology to a known role," which means that technology is being created so that the technology can be applied to a production or consumption operation that makes profit for its inventors.

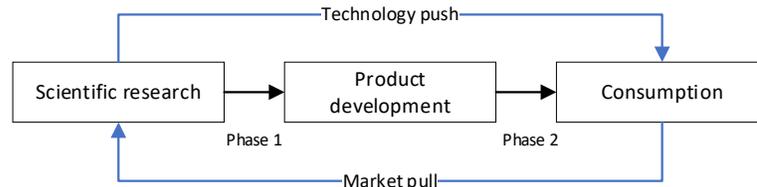


Figure 1. Technology development process (Parker and Mainelli, 2001)

There are usually two common ways to differentiate between drivers of innovation (Boehme and Stehr, 1986). The source of innovation is currently insufficient customer satisfaction and new problems for the solution (invent-to-order) are needed as a result of market pull / demand pull / need pull. The desire comes from people or individuals who express their subjective demands. Push technology is the catalyst for new technologies and processes extracted from research (internal or external); the goal is to leverage new know-how commercially. The impulses are triggered by the technological capacity to be applied. It does not however matter whether or not a certain request exists. Gerpott (2005) distinguishes in this sense between innovation's high and low 'new' characteristics, and thus between revolutionary ('technology push') developments and incremental ones ('market pull'). Technology drive can also be defined as creative / destructive with significant and new changes, but a replacement or a substitution is the pull of the market (Walsh et al., 2002).

The commercialization process of R&D institutions' intellectual property and higher education institutions indicates that the marketing mechanism is institutionalized. Through having complete support from the company, intellectual property can be promoted through marketing through this Technology Transfer service unit. This process also requires researchers to uncover research results that can protect their intellectual property, which can in turn expand the IP Portfolio of the institution. A team at the business office / technology transition will then review this portfolio to prepare the marketing strategy and the appropriate investment allocation or budget. The marketing path shows that in addition to the targeted number of licenses, the establishment of a commercialized new technology company could also be one of the goals of marketing itself.

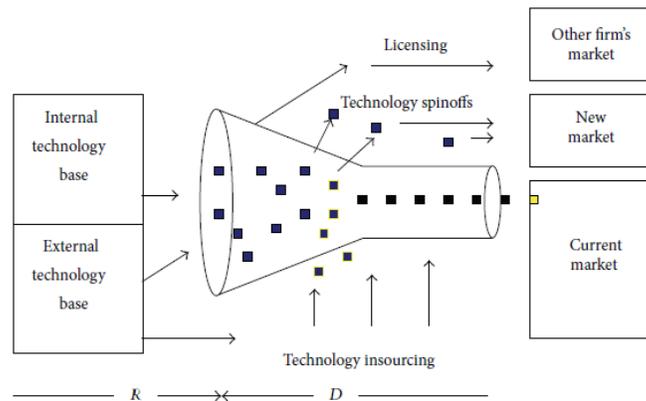


Figure 2. The open innovation paradigm (sources from Chesbrough et al, 2010).

Figure 2 shows the relation between efficiency of transfer of technology and open innovation with the open paradigm of innovation (Chesbrough et al, 2010). Many new technologies are resulted from researches conducted by university

and R&D centre. However, not all of these technology products can develop in the market. In order to accelerate the technology commercialization, both internally and externally, technology insourcing is therefore needed. It involves the provision of physical facilities in the area of marketing technology, mentorship and coaching programs, marketing and company networking, financial support, and internal regulation itself. In this case the TTO is also involved in the introduction of incubation technology. The university will also take part as spinoffs, in which a TTO is responsible for technological incubation (Sutopo et al, 2019).

A research that produces technology products will have a high market aspect, useful and marketable if it has a high level of technological readiness, a level of innovation readiness and a high level of manufacturing readiness. Without these three readiness processes, an innovation will fall into the Valley of Death and if it enters this valley, a long and complex product of innovation will be difficult and will never be able to rise again (Prasetyono, 2017). The Valley of Death is a common term of business worldwide in connection with the major challenge of dealing with adversely affected cash flow in the early phases of a new venture before real-life customers generate income from innovation (service or product) (Osawa & Miyazaki 2006). The Valley of Death is often referred to as a big innovation management challenge, meaning that the divide between academia and industry remains (Bhushan, 2015). Figure 3 represents the valley of death in innovation process.

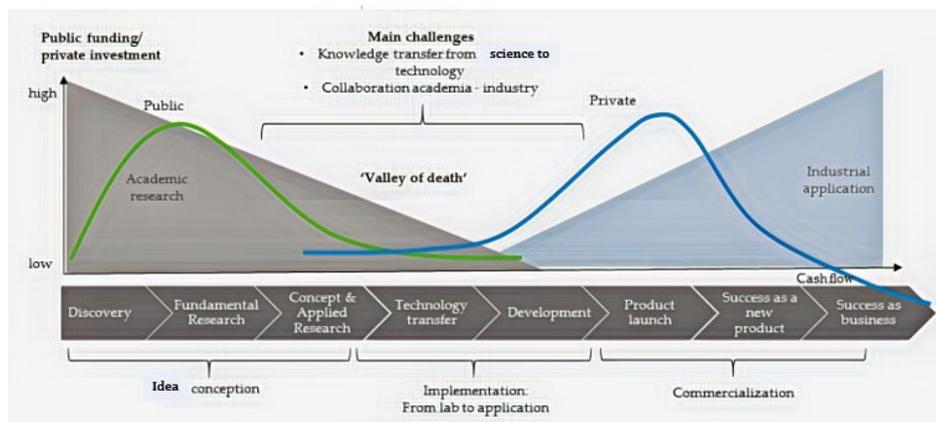


Figure 3. The valley of death in innovation process

2.5. Framework selection

In this paper, we conducted a comparative analysis of the development of battery technology in Indonesia. We use a technopreneurship and innovation system approach to understand the process of innovation management at the relevant TTO and how the technopreneurship model is applied. Meanwhile, aspects that will be reviewed include technology development whether included in the market pull or demand push. In addition, we also analyze the innovation paradigm and degree of product innovation, whether classified as closed innovation or open innovation. Next, the product development process model and the innovation management model are also considered. Furthermore, we analyze the technological innovation ecosystems involved and the role of the TTO in each innovation to commercialize technology.

Data collection was done using Google's search engine by typing the keywords for each technology name. Based on each search result. Based on the search results, we chose the relevant literature to be used as discussion materials in this case study. Figure 4 illustrates the framework of this study.

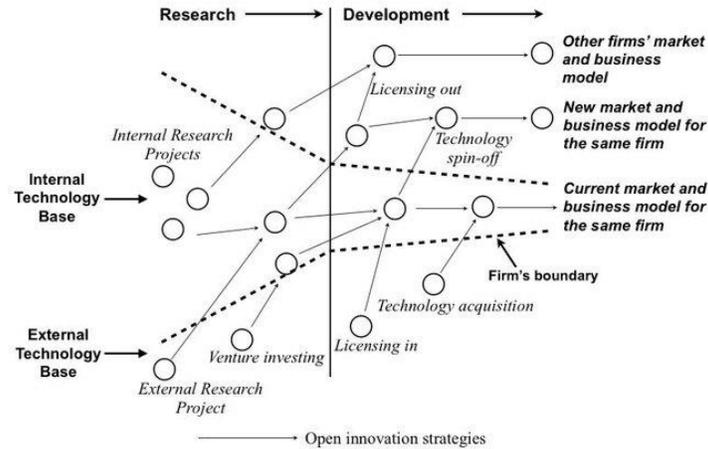


Figure 4. Framework of the study

3. Result and Discussion

The paper provides an insight into how technology transfer offices (TTO) organize and manage innovation activities with the technopreneurship model and how the constraints of technology commercialization on battery technology innovations. The paper highlights the advantages and challenges of innovation as a management process, open innovation paradigm, and the role of technopreneurship model in technology commercialization. This paper also ascertains the crucial role of TTO in the innovation system for successfully commercializing technology innovations.

We considered eight innovations in this study. Some of which were invented by government, university, or research agency. Table 1 provides details regarding the innovations studied in this paper, whereas Table 2 provided information regarding the extent to which innovation has progressed.

Table 1. Innovations details

Innovation's name	Label	Year invented	Inventor	Existence of incubation centre	Existence of start-up
lithium battery made from solid ceramics	T1	2009	non-ministry government institution	V	-
lithium battery UNS	T2	2012	university academics	V	V
lithium battery made from rubber cassava starch	T3	2014	research and development institution under ministry	-	-
coconut shell, tea powder, and biomass as carbon material for lithium battery	T4	2018	non-ministry government institution	V	-
batteries made from burned peatlands	T5	2020	university student	-	-
sodium battery from <i>salak</i> rind	T6	2018	university academics	V	-
Gesits	T7	2007	university academics	V	V

Table 2. Innovations progression

Innovation	Discovery	Fundamental research	Concept & applied research	Technology transfer	Development	Product launch	Success as a new product	Success as business
T1	X	X	X	X	X			
T2	X	X	X	X	X	X		
T3	X	X	X	X	X			
T4	X	X	X	X	X			

T5	X							
T6	X	X	X					
T7	X	X	X	X	X	X	X	

Based on the data in Table 1 and Table 2, we can identify several points. Of the eight innovations studied, five of them already have business incubators in related institutions (T1, T2, T4, T6, T7) and there are only two technologies that have been started by certain start-ups (T2 and T7). T5 is a technology that is still in its early stages because it is only in the discovery phase. Whereas the T6 is still in the concept and applied research phase. Furthermore, T1, T3, T4 have reached the development phase because all three of these technologies have been tested in the laboratory but are still under development to perfect the product.

These seven technologies cannot yet pass the value of death. T1, T2, T4, T5, T6 have not implemented technopreneurship properly because some technologies have not yet been registered in the incubation program even though they already have an incubation center at the R&D center. In fact, technology incubation has a role in turning R&D inventions or results into commercial products and the birth of a start-up company. Technology incubation needs to be done for the five technologies and is directed at the maturity of the technology that will be developed through the process of R&D, prototyping, product testing, and certification. Whereas business incubation can be started from a business feasibility study and preparation of a business plan, business mediation, as well as initial funding for startups and market expansion requirements.

3.1. Case study from university’s innovation: T2 and T7

Meanwhile, T2 and T7 have not been able to cross the valley of death even though they already have a startup to run a technology commercialization business. Here we present a brief case study for T2 and T7.

3.1.1. T2: lithium battery UNS

UNS as an incubation center for lithium battery technology for electric vehicles, started its research in 2012-2014 in the context of developing a national electric car. One year later, the university began production on a laboratory scale, then in 2016 to 2018 it began the scale of battery production on a mini plant scale.

Smart UNS, product of the innovation in the field of lithium batteries, has two different types: LFP 18650, NCA 18650, 3,2 Volt and 3,7 Volt voltage and 1400 mA H and 2700 mA H capacities. This battery is very safe with LFP technology because in case of a short circuit it does not cause an Explosion. In addition to being recharged and economic this battery is able to withstand relatively high temperatures, up to 70 ° C, with a long life of up to 3000 usage cycles and is longer than existing consumer batteries (500 cycles).

The method used for manufacturing does not create waste that is environmentally harmful. The production process is also fitted with standard-specific equipment. It can be used for electric vehicles , electric bicycles, road lights, JPUs, laptop PCs, toys, UPSs and power banks. Smart UNS has partnered with Pertamina, the Department for Science, Technology and Higher Education, and the LPDP[1] to finance growth.

One of the rising national electric motor industries, namely the electric motor GESITS, is expected to supply the UNS lithium battery. Viewed by the same-class rivals the Honda costs up to Rp. Sixty million, sold for just Rp by GESITS. 23 million, 30 percent of cost was focused on the battery. The production of lithium batteries currently in the industry[2] is highly suitable for UNS[1]. Moreover, as a supply supplier and manufacturer of the first lithium battery in Indonesia, it is expected that the university will become an independent business entity in the future.

Several researches on the lithium battery technology development have been done. The methodology to establish the Indonesian National Standard for Cell Lithium-Ion Battery Secondary Standard for Electric Vehicle Applications was evaluated by Sutopo and Kadir (2017). The parameters for the Battery Management System (BMS) standard were reviewed by Sutopo et al (2018). The lithium-ion battery module product standardization framework was created by Sutopo and Kadir (2018) using the Standard Testing, Comparison and Analysis Framework (STAF) approach. In the meantime, Rahmawati et al (2017), using the Battery Management System (BMS) for electric vehicles, used FACTS in the development of standardization and testing criteria. The scientific feasibility analysis for the marketing technology of lithium ion battery was performed by Atikah et al (2014). A case study of the lithium-ion battery module for the application of electric vehicles has also been developed by Aristyawati et al (2016) for the standardization and testing requirements of secondary battery. Sutopo et al (2013) also carried out battery technology analysis of electric

vehicles in comparative value chains. Prianjani et al (2016) have established the Indonesian National Standard (INS) for the Lithium-ion Ferro Phosphate Secondary cell traction battery for use in electric vehicles. In order to determine the feasibility of developing Li-ion batteries by target market strategy, Sutopo et al (2014) proposed a cost estimation model.

The existence of a TTO supported T2 innovation management. In order to manage research products created by university researchers, the University has developed TTO. A lithium LiFePO₄ (LFP battery) is a development product produced by the university. The TTO has an operating facility for the manufacture and sale of LFP batteries. Since the business unit has not been pioneered recently, TTO is still continually improving its marketing capability to optimally market the product (Sutopo et al, 2019).

3.1.2. T7: Gesits electric motorcycle battery

Currently, environmentally friendly technology is being applied, one of which is the use of electric motorbikes. Not only environmentally friendly, electric motors are also efficient and effective as urban transportation. Before seeing how it develops in Indonesia, let's first know what an electric motorcycle is. Electric motorbikes are motorbike vehicles that move without oil fuel. Electric motors are driven by dynamos and accumulators.

Until now, in Indonesia there are already available types of motorbikes with speeds of 60 kilometers / hour, equipped with disc brakes, near and far lighting lamps, turn signal lights, brake lights and horns. Electric motorbikes began to be developed in Indonesia in 2007. Although they have been developed since 2007, the prototype of an electric motorbike named Gesits only began to be exhibited in 2015. At that time, it only showed the movers.

Then in 2016, 5,000 units of Gesits electric motorbikes began to be ordered by PT. Telekomunikasi Indonesia Tbk. This electric motor has been tested along Jakarta-Bali. In 2017, a motorcycle production cooperation agreement was signed between PT Gesits Technologies, PT Wika Industri and Construction and PT Institut Teknologi Sepuluh November. From there, signs of Gesits produced increasingly visible.

Furthermore, in 2018 President Jokowi had a chance to try Gesits by going around the Palace for 3 minutes. The following year, April 2019 to be exact, the Gesits electric motor was launched.

GESITS has placed two Battery spaces in the compartment under the seat. Consumers can use two batteries by way of parallel batteries 1 and a second battery, so consumers do not need to stop replacing / recharging batteries when browsing exceeds 50 km. This national electric scooter requires around 1.5 - 3 hours for charging the battery through a socket.

Previously, Gesits claimed to be ready to do a battery swap system to facilitate consumers who do not have time to charge. However, it still seems to be a discourse because to do the system requires a large investment and the supply of batteries more than the number of vehicles in circulation. For the time being, the swap system is still within the company's target. Currently the products sold are still using batteries, because the swap requires a much larger investment. But actually, the Gesits motor has been designed swap ready so that the batteries can be replaced.

Innovation management at TTO

Thanks to the success of spawning electric motors made by domestic children, the Institut Teknologi Sepuluh November (ITS) is increasingly serious in developing the electric automotive industry in Indonesia. Garasindo Electric Scooter ITS (Gesits), established the first teaching industry in Indonesia that focuses on developing the electric motorcycle assembly industry. The first teaching industry in ITS is ready to facilitate various problems in the development of the electric automotive industry in Indonesia.

The teaching industry funded by the Ministry of Research and Technology can be a whip for university researchers to immediately realize the research they have because research is only limited to publication and cannot be absorbed by industry is not innovation. Innovation must be able to be utilized and commercialized. Through the teaching industry which is shaded by the Center for Science and Technology Technology (PUI) for Automotive Systems and Control (SKO) ITS, ITS is expected to succeed in creating electric motors with competitive prices and the best quality so that electric motors can shift the needs of motorcycles in Indonesia. Teaching industry is a balanced form of the role of universities in developing and preparing reliable human resources to support the mass production process. In addition, through this teaching industry training program students are expected to have a shadow about how the automated industry actually takes place.

In line with this, with the eight manufacturing processes currently owned, the first teaching industry at ITS has succeeded in producing an electric motor with a waiting time of 5 minutes and the entire assembly process for 45 minutes through the concept of modular assembly. The concept of modular assembly is very suitable to support the educational process because the configuration can be changed as needed. In addition, this is also supported by all facilities in the teaching industry that are designed themselves according to needs.

This concept also supports the process of developing a new variant of Gesits that can be tested first in the teaching industry before mass production or other parties engaged in the electric motor industry. Besides involving ITS students and college graduates. The Teaching Industry with 25 technicians also involved elementary, junior high, and vocational high school graduates in the manufacturing process. The teaching industry is believed to be able to produce new innovations and provide various development solutions in the Indonesian electric motor industry through teaching industry facilities that are owned for the development of Indonesian Automotive technology.

3.2. Lesson learned

Based on the analyzes made, we can know that TTO is a great part of battery technology 's success. The primary objective of technology transfer (technology transfer developed by university scientists to the private sector) is to improve national economic development through increased technological innovation. Technology transfer directly contributes to technological innovation by supplying new, commercially potential technologies to the private sector. Although corporations look forward to new products and services, universities are inspired by future revenue streams from successful licensing deals and expanded jobs with business partners. Technology Transfer Departments, such as a university or a research agency, oversee and protect the intellectual property of a scientific organization. Through the licensing, patents or management of spin-off creations, the TTOs promote the marketing of intellectual property collected with research-based data.

The paper includes several possible effects for the manager's TTO, including the role of inventors, R&D centres, and start-up play in technological entrepreneurship development. No doubt, it is necessary to promote and facilitate technopreneurship. Nevertheless, all aspects of technopreneurship should be carefully and thoroughly considered in order to better appreciate the complexities of each stage of the growth of technopreneurship. To order to develop goods that are technically effective and economically competitive and suited to consumer needs, R&D capacity must be constantly improved. Successful technology transmission calls for relevant , reliable and competitive technologies. In addition, support from the government is necessary to establish spin-off companies; the absorption capacity of established companies must also be increased. All that will improve the technology market.

Van Gils & Rutje (2017) has indicated that the most significant "open innovation" platform for start-ups seeking to expand is the innovation biotope, a well-definable cross-company segment of an ecosystem. The business challenge at stake is that all biotope participants are carefully selected; they can enter the safe marketplace only when start-ups can deliver dedicated solutions. The biotope enables 'open innovation in a closed network' that accelerates the cycle of innovation.

For T2 and T7, if they were able to handle open technologies with larger organizations, they would benefit from overcoming the burden of younger and smaller (Usman and Vanhaverbeke, 2017). Start-up managers play a crucial role in developing and promoting open innovation management activities in order to effectively incorporate open innovation in a start-up. Policymakers will help businesses in order to compete in an open cycle of innovation and invest in the growth of management skills.

4. Conclusion

Comparative analysis of the battery technology development has been carried out. This paper provided a study of technopreneurship model that is suitable for a technological, based on comparative study between three innovation products. The analysis was conducted by referring to the technopreneurship and innovation system approach to understand the process of innovation management at the relevant TTO and how the technopreneurship model is applied. Based on the analysis that has been done, Technology Transfer Offices (TTOs) are the key of success in managing battery innovation.

The paper is a step forward in filling the literature gap about technopreneurship and innovation systems with some definite implications for technology commercialization. A lot is written about the collaboration between technopreneur and innovation systems, but the technology commercialization's perspective has been left unexplored.

This research is based on a comparative analysis based on a case study, so the conclusions drawn from these cases may be hard to generalize. The findings of the study could be developed lessons learned in the success of technology commercialization. Future research, including quantitative studies, will help examine the conclusions and provide a more in-depth understanding of technopreneurship and innovation systems.

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