The Role of Technological Entrepreneurship and Innovation System for Commercializing Electric Motorcycle Conversion Kit: A Case Study

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Abstract

Technology will continue to develop as time goes by and human needs are increasingly complex. One of the issues currently being discussed is the issue of sustainability and renewable energy to reduce high air emissions. The Indonesian government aims to reduce carbon emissions, one of which is by increasing the number of electric vehicles used. Convertible electric motorbikes are a technological innovation that comes from university research. In order to support the development and commercialization of conversion kit technology, a model framework is needed. This research discusses the technological entrepreneurship and innovation system model that is suitable for the development of supporting technology for electric convertibles produced in Indonesia. Meanwhile, other aspects that will be discussed regarding technology development, namely technology push or market pull. Furthermore, the product development process is also discussed to find out how to prevent technological innovation from falling into the valley of death. This study aims to develop strategies and provide lessons learned to readers so that technology commercialization can run well. The results of the analysis show that the conversion kit technology innovation currently still requires outreach because public interest is still not large, besides that the supply chain network of a conversion workshop is still not clearly defined. So that over time, the government and the conversion workshop work together to develop a supply chain for conversion kit components.

Keywords

Electric Vehicle Kit Conversion, Technological Entrepreneurship, Innovation System, Commercialization, SWOT Analysis

1. Introduction

In 2016, Indonesia along with 171 other countries in the world signed the Paris agreement at the United Nation Headquarters, New York, United States. This agreement is a global agreement in dealing with world climate change. As one of the countries with the sixth largest carbon emissions in the world, Indonesia has a role as part of the global

movement to tackle climate change. The transportation sector is the largest emitting sector after industry. So that one of the steps that can be taken in order to increase energy efficiency and efforts to reduce greenhouse gas emissions to achieve net zero emission is to accelerate the ecosystem of battery-based electric motorized vehicles (Rahmawati et al. 2022).

Government support for the motor vehicle ecosystem acceleration program can be seen in government regulation number 70 of 2009 concerning energy conservation and presidential regulation number 55 of 2019 concerning accelerating the battery-based electric vehicle program for road transportation. There are two types of electric motorcycles circulating in Indonesia, namely new design electric motorbikes and convertible electric motorbikes (Utami et al. 2020). Convertible electric motorbikes are a new technology in Indonesia. Convertible electric motorbikes are one result of an innovation system. This product was designed due to higher carbon emissions. This can be seen from the increase in the number of Internal Combustion Engine (ICE) motorcycles. In Indonesia it reached almost 300% from 2007 to 2017. Therefore, it will automatically increase carbon emissions. Now, all state governments are trying to reduce carbon emissions from the transportation sector (Bonilla & Merino 2010). The transportation sector is one of the largest sources of carbon emissions in the world (Solaymani 2019).

One of the steps taken by the government in order to increase the number of electric vehicles in Indonesia is to provide assistance in the form of subsidies for the purchase of new electric motorbikes and convertible electric motorbikes. Minister of Energy and Mineral Resources Regulation No. 39 of 2023 explains the technical guidelines for the implementation of government assistance in the conversion program of electric motorbikes (ICE) into battery-based electric motorbikes. The existence of technical guidelines can make conversion actors in Indonesia have standards so that people who will use conversion services to convert gasoline-fueled motorbikes to battery-based motorbikes.

The basic innovation idea for converting electric motorbikes is reducing carbon gas emissions by replacing the engine on an ICE motorbike with an electric power source. The conversion of electric motorbikes is one of the results of management innovation. Management innovation comes from creativity and has the ultimate goal of being competitive (Carayannis et al. 2015). This innovation will make it easier for customers because customers do not need to buy a new motorbike if they want to use an electric motorbike. They just need to convert their old motorbike, and they can use it with an electric motorbike. They have to replace the machine with a conversion kit which is battery, BLDC and controller (Habibie & Sutopo 2020)

This study discusses university spin-offs in Indonesia related to technology products. The company's main product for the past 2 years is a conversion kit to convert a conventional motorcycle into an electric motorcycle. The conversion kit technology has gone through a testing process in an incubation scheme using the Technological Readiness Level (TRL) to be commercialized. Technopreneurs play a role in preventing spin-offs into the 'valley of death' by using a bridging system between technology and business.

1.1 Objectives
This study aims to develop strategies and provide lessons learned to readers so that technology commercialization can run well. In addition, this research also explores current problems related to conversion kit technology innovation.

2. Literature Review
2.1 EV Conversion
Habibie et al. (2020) mentions that electric motorbikes are divided into two types, namely new design electric motorbikes and convertible electric motorbikes. Electric motorcycles have a low noise level and are energy efficient. Bureaucracy regarding electric vehicles is something new in Indonesia. Indonesia is one of the countries that applies convertible vehicle technology. Mohamed-Nour et al. (1997) stated that conventional vehicle conversion technology is one of the solutions that can support the increasing number of electric vehicles.

2.2 Innovation as a Management Process
Innovation management is an interactive process that is complex and risky (Cooke et al. 1998). There are 5 steps taken in the innovation process, namely composing new ideas, redesigning the production process, knowledge management, product development, and redesigning the marketing process. Technological innovation management still has obstacles, namely high uncertainty, ambiguity, and risk. Innovation management is a highly collaborative process. This is a consequence of the continuous transfer of information between different parties, where each team member

can play a major role in the final outcome. Innovation seems to work at times in the short term but not so much in the short term as in the long term. The key factor is also the optimistic aspiration for future technical progress and the lack of insight into unforeseen influences. The second point is that a scientific or technological problem is the basic obstacle in only a few cases. Organizational, financial and operational problems are usually hampered.

Creativity management is complex and carries risks. Among other issues, a study of the literature by other businesses reveals that many creative companies have not turned their technical innovations into successful businesses. So, the challenge is not only to build creativity, but also to manage it well to generate profits in business. It is clear that the organization's position in innovation management is a mechanism that must be developed and used to achieve a healthy organization (Carayannis et al. 2015).

2.3 Innovation Systems

Innovation is not only the creation of ideas into a product, but also includes the commercialization process so that the idea can be accepted by society (Freeman & Luc, 1997). The innovation system is seen as open, dynamic and social which implies that innovation is created from social interaction between economic actors (Lundvall, 1992). This indicates they are communicating with their device's environment. (Carayannis & Campbell, 2009) mentions that one must clearly demonstrate that a system's model must coexist with many other ideas, such as innovation networks and information groups, to understand the value of systems (and systems theory). Interaction, synchronization, complementarity and enhancement are the main areas of network focus. For example, a network can be thought of as the internal structure that unites and defines a cluster. The strategy for the innovation process is based on a systemic approach which implies that markets do not develop or function outside of their laws and institutions. The aim of the innovation program is to develop, disseminate, and utilize innovation.

2.4 Technological Entrepreneurship (Technopreneur ship)

Dorf and Byers (2005) defining technological entrepreneurship is a leadership style by identifying high potential, high technology commercialization opportunities, opportunities to gather resources (talent and capital), and manage rapid and risky growth. The hidden idea that is fundamental to many core issues is technological entrepreneurship. Various literatures explain, using the terms "technology-based businessman", "technology-based entrepreneur", or even "high-tech new business" (Florida & Kenney 1988; Kakati 2003).

The technology-oriented entrepreneur is a technically engaged process and development of new companies, which use technological inventions by "technopreneurs." Technological entrepreneurship is the process of investing in a project that brings together and activates professionals with various assets related to the promotion of knowledge science and technology to build and derive value for a particular company and also plays an active role in developing this concept in the social context in which the entrepreneur operates. Technological entrepreneurship aims to market inventions created by academic scientists through patents, licensing, startups and collaborations between universities and industry (Grimaldi et al. 2011).

The technology development cycle is primarily concerned with the technical developments in which technology can be used by businesses to create, produce, and provide their goods and services as a technical system and practical knowledge and capabilities, so that they can be defined and embedded in personnel, facilities, equipment and physical procedures. and technological entrepreneurship operations is the creative application, individually or in groups of individuals, of techniques and skills that generate and manage businesses and take on financial risks for that purpose and outlook. In this way, engineers have strong technical qualifications but also lack business and strategic thinking skills (Prodan 2007)

2.5 Technology Push Vs Market Pull

One of the implementations of the technology push strategy is the development of GC Helmet product innovation which is based on technological developments carried out by inventors over the years. This strategy has several drawbacks in terms of market acceptance because it is not an item that is needed by the current market (Tan et al. 2019). While Market Pull is an innovation that starts from market needs. This conversion kit technology departs from the technology push carried out by universities, then supported by a government program, namely the acceleration of the battery-based electric motor vehicle program.

2.6 SWOT Analysis

SWOT analysis is a strategy matrix for evaluating a project (Parnell, 2013). SWOT analysis looks at the extent to which an organization's internal environment (strengths, weaknesses) matches the external environment (opportunities, threats) according to the business model. Researchers developed and refined the SWOT analysis based on internal knowledge derived from engagement with development partners and external feedback from researchers.

3. Methods

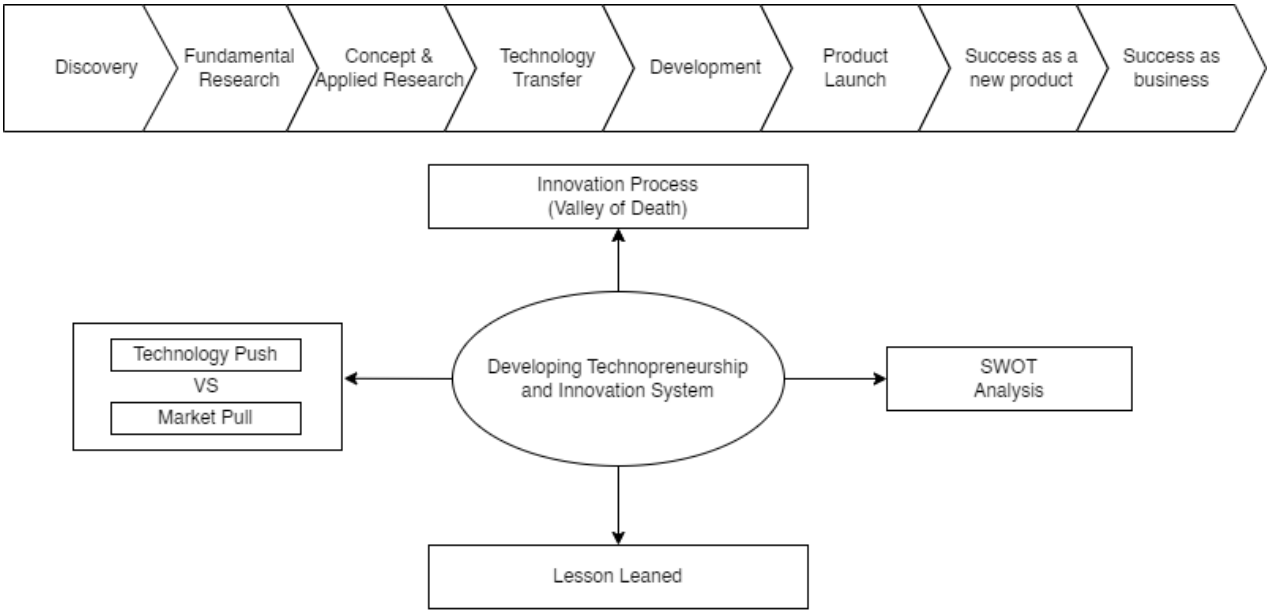

Figure 1. Technological Entrepreneurship and Innovation System Framework

In this study, the technological entrepreneurship and innovation system framework combines three concepts, namely the innovation management process, comparisons between technology push and market pull, and SWOT analysis and then draws conclusions in the form of lessons learned. This study uses data obtained from interviews and studies of previous research literature. Figure 1 shows the technological entrepreneurship and innovation system framework used in this study.

(Siyanbola et al. 2011) stated that there are several roles of technological entrepreneurship in socio-economic development, namely requiring the support of technological innovation to be able to enter the market. Technological entrepreneurship can increase a country's technological capabilities because technological entrepreneurship will always develop the commercialization of research results, more patents are granted, and patents are an indicator of the popularity and size of a country's technological development and industrialization throughout the world. Technological entrepreneurship is a platform that accelerates the successful diffusion of technological innovations in the economic sector. The main role of technological entrepreneurship is to find market needs and become a problem solver for the technological entrepreneur to become a relevant solution.

Research that produces a product in the form of technology will have a high market aspect, the criteria are useful and suitable for the market, it has a fairly high level on the technology readiness level, namely an innovation readiness level and a manufacturing readiness level. Without an evaluation process for technological readiness, it is feared that an innovation will fall into the valley of death and when it enters this valley, it will be difficult for complex innovation products to emerge.

Market pull and technology push is a model used to differentiate technological innovation from the customer's point of view. Technology push begins with a product research and development, then the production process is carried out

so that it can be released to the market. Meanwhile, market pull is a reciprocal relationship with the customer, where the customer provides criticism and suggestions for product development.

(Ghazinoory & Ghazinoori 2006) stated that SWOT analysis is an integral part of the birth of technology that comes from the innovation process. SWOT analysis helps analyze and evaluate the development of a technology that is entering the commercialization phase. SWOT analysis is a tool used to plan and understand the four criteria that exist in a project, business or technology. Before conducting a SWOT analysis, it is necessary to determine objectives and identify internal and external factors that are supportive or unfavorable. SWOT analysis is often used as part of the strategic planning process.

4. Data Collection

Data collection was carried out by conducting direct interviews with company stakeholders and literature studies. Interviews with stakeholders of PT. XYZ is carried out to find out how the company's current condition is both from the internal and external sides of the company. The results of the interviews were then analyzed by the authors and then used as material for evaluation using the proposed model framework.

A literature study was carried out by looking for references to articles that discussed the development of conversion kit technology, especially conversion kits for motorcycles. There are not many literature studies that discuss electric motorbike conversion kits, so the authors also use other references that discuss the electric vehicle ecosystem in Indonesia.

5. Results and Discussion

5.1 Technology Innovation and Business Process

Conversion kit of convertible electric motorbikes is one solution that can be done to reduce carbon emission levels caused by the transportation sector. This reason is the basis for the idea of the emergence of technological innovation. The government provides support regarding the electric vehicle ecosystem through Presidential Regulation Number 55 of 2019 concerning the acceleration of the battery-based electric motorized vehicle program. The government through the Ministry of Energy and Mineral Resources is targeting the number of electric motorcycles to reach 6 million units to create an electric vehicle ecosystem with the hope of saving 13 million barrels/year of fuel, reducing CO2 emissions by 4 million tons/year, and increasing electricity consumption by 2.4Watt hour (TWh)/year. Currently, the conversion kit technology has entered the product launch phase and is supported by the Minister of Transportation Regulation Number 65 of 2020 concerning the conversion of electric motorcycles to battery-based electric motorcycles. Conversion kits are currently produced by conversion workshops that have been certified by the ministry of transportation. There are 22 conversion workshops in Indonesia that act as manufacturers and assemblies of conversion kit components. The government supports the program to accelerate the electrification of motorized vehicles by providing a subsidy of IDR 7 million for every purchase of a new design electric motorbike and conversion from a combustion engine to an electric one.

The main components of the conversion kit are the BLDC motor, controller and battery. The supporting components that make up the conversion kit consist of a speedometer, throttle, mcb, dc-dc converter, swing arm, pulley, wiring, bolts, battery socket and bracket set. An illustration of the components that make up the conversion kit is shown in Figure 2.

Figure 2. Two-wheeled Motorized Vehicle Conversion Kit Composition Components

The procedure for implementing the conversion has also been stipulated in the ministerial regulation of energy and mineral resources number 23 of 2023 concerning general guidelines for government assistance in the conversion program of electric motorcycles to battery-based electric motorbikes. This policy is one of the steps to increase energy efficiency and efforts to reduce greenhouse gas emissions to achieve net zero emission. The government has also established a process flow for the conversion of vehicles as shown in Figure 3.

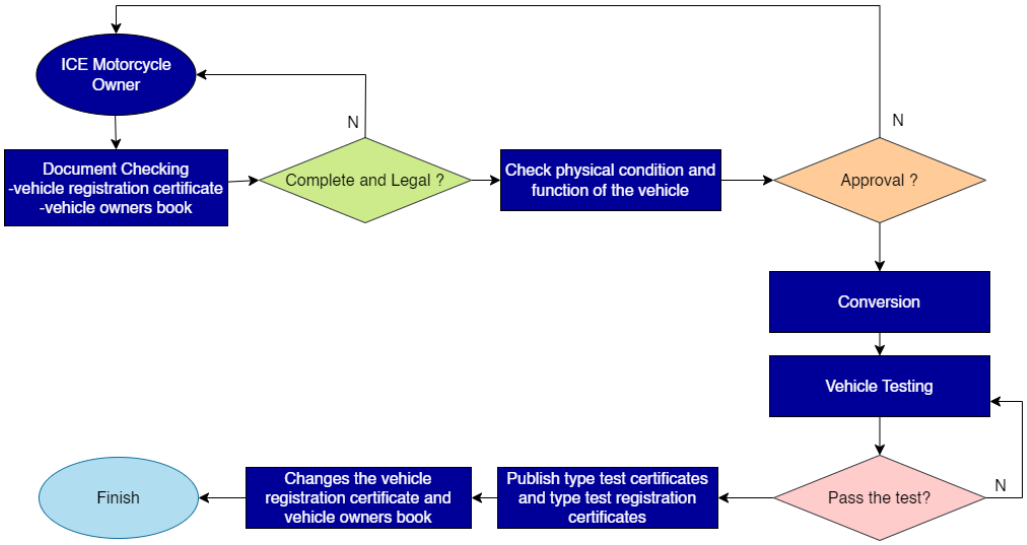

Figure 3. Flow of the Convertible Electric Motorbikes Process

The process of converting a conventional motorbike begins with the owner's approval to carry out the conversion at a conversion workshop that already has certification from the ministry of transportation. Furthermore, the conversion workshop will check the physical condition of the vehicle and vehicle ownership documents. If it is complete and legal, it will proceed to the conversion process and vehicle testing. Vehicle testing is carried out by the conversion

workshop and continued by the roadworthiness testing center. This stage aims to ascertain whether the vehicle complies with user safety and security procedures. If the vehicle has gone through the testing process and passed, a type test letter and a type test registration certificate will be issued. So that the conversion vehicle is legal, the ownership documents have been updated with specifications, and declared fit for use on the streets.

5.2 Technology Push VS Market Pull

The electric motorbike conversion kit has the advantage of being flexible in its use. The conversion kit produced can be used for all types of vehicles, both automatic and manual. The electric motorbike conversion kit comes from ideas and research that go through a development process so that these technological products can be present on the market. However, at the beginning of this conversion kit product development research also came from the problem of carbon emissions in the air which became the government's concern.

Over time, government policies and regulations that support the development of electric vehicles. In 2023, the government will also issue subsidies for the purchase of new electric cars and electric motorbikes as well as conversions. With this support, the concept of electric motorbike conversion technology has become a market pull that has begun to bring in new customers.

The development of this conversion kit technology innovation is a combination of technology push and market pull. This is one of the steps taken by technology inventors so that a technological innovation does not fall into the valley of death.

5.3 SWOT Analysis

This study uses SWOT (Strength, Weakness, Opportunity, Threats) analysis tools to formulate an innovation strategy for electric motorcycle conversion kit technology. The analysis was carried out using the SWOT method. SWOT analysis is shown in table 1.

Table 1. SWOT Analysis of Electric Motorcycle Conversion Kits

Strengths	**Weakness**
- The first vehicle conversion workshop in Central Java - Having competent human resources - Have conversion kit patent	- Purchase of raw materials from abroad (import), if the purchase in large quantities will be subject to tax - Marketing reach has not expanded - Many ordinary people do not understand what a motorcycle conversion is
Opportunities	**Threats**
- Government policies namely incentives for the purchase of electric motorbikes and vehicle conversions - By converting, the main engine components used are of good quality - Guarantee the safety, comfort and safety of users - Product variants vary and can be adjusted to the wishes of the user	- Have competitors of similar products and substitute products - Price competition among competitors' products

Lesson Learned

Based on the analysis that has been prepared, it can be seen that a technopreneur has a superior role in the process of technology commercialization. The main objective of the technology transfer process (technology transfer developed by university researchers in the manufacturing sector) is to increase global economic value through technological innovation. Technology transfer directly contributes to technological innovation to supply new ideas and commercialize potential technologies.

In developing the conversion kit innovation technology for electric motorcycles, three things must be managed, namely managing knowledge, managing relationships, and managing technology and infrastructure. Knowledge is related to the pattern of research and technology development carried out by the Research and Development team of a conversion workshop or collaboration with research and educational institutions that specialize in that field. There

needs to be good collaboration between universities and academics of an institution to increase technological variations such as joint research projects.

Relationship is related to the relationship between the conversion workshop and customers and suppliers or can be called a supply chain network. Current conditions make conversion workshops have to import products from other countries to be able to meet the demand of potential consumers, while on the other hand the government is also supporting so that the value of the domestic content level of conversion kit products can be superior. In the case of new design electric motorcycles, the government only provides subsidies or assistance to electric motorcycle brands that have a domestic content level value of at least 40%. Furthermore, the government is also starting to prepare a strategy to be able to apply this to electric convertible motorcycles, so that the use of domestic products can be more optimal.

Technology and infrastructure participate in supporting the electric vehicle ecosystem in Indonesia. The government through the Ministry of Energy and Mineral Resources has prepared a roadmap for battery-based electric motorized vehicles up to 2030. A technological entrepreneur needs to prepare a strategy to manage the available technology and infrastructure, including providing proposals regarding the provision of infrastructure that supports increasing electric vehicle users, namely battery swap system. With the existence of infrastructure that supports one's mobility when using an electric vehicle, users will not have to worry about using the vehicle.

Conclusion

This study aims to develop strategies and provide lessons learned to readers so that technology commercialization can run well. In the process of determining the company's strategy, researchers obtained data based on brief interviews and literature studies from articles and journals that discussed conversion kit technology. The conversion kit is a technological innovation that was born from a series of research and development processes carried out by the university, then came into being as a spin-off university called PT. XYZ. The researcher acts as a technology entrepreneur trying to provide suggestions and solutions for companies regarding what companies can do in order to continue to earn revenue while keeping conversion kit technology innovation from falling into the valley of death. One solution that can be proposed is to maintain the quality of the conversion kit manufactured by the company, but still maintain a selling price that can compete with other competitors. So that potential users will have the view that conversion kit technology, which is the result of university research and development, has high competitiveness when compared to other products.

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Biography

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