Timing Model to Launch Spin-off Company: The Case Study of Mini Manufacturing Plant of 10kWH Li-ion Batteries

Rina Wiji Astuti, Yuniaristanto, Wahyudi Sutopo, Agus Purwanto, Muhammad Nizam

***Abstract*— Spin-off is a company that exploits a university or research intellectual property that is characterized by the maturity of a technology. An academic spin-off is an enterprise of which the business activity is founded on a technological development or innovative concept developed at the university. The economic scale of this company must be small. At the beginning, this company starts-up on a inception stage, then moves to a formative stage, after that prepares for expansion and fight for national market share. This paper develops a framework to solve the timing problems with using the model approach used to launch spin off company. Appropriate time for launching can be assumed to be some meaning for successful operations, and often a certain action is possible only during a given period. This paper also analyzes the theory of organizational life cycle, Technology Readiness Level (TRLs) and Demand Readiness Level (DRLs) evaluation. The results of this paper is a model used to determine the optimal time that is used to launch a spin-off company. In order to shorten the time, can be done by accelerating the achievement of TRLs-DRLs and capacity building.**

***Index Terms*— DRLs, spin-off, start-up company, TRLs, timing model.**

I. INTRODUCTION

The commercialization of science and technology has become a prominent issue in the Indonesian policy agenda [1]. Despite the relatively new interest from a policy point of view, it was the subject of academic interest long before. In a comprehensive review of research and theory regarding technology transfer, Bozeman [2] reports: "in the study of how to commercialize research, the neophyte and the veteran are easily distinguished. The neophyte is the one who is not confused….".

Much of the academic work has been focusing on "technology transfer" from research organizations or universities to the incumbent industry [3]. Conversely, much less is known about "creating new ventures" as a way to commercialize research and technology. This does not mean, however, that creating spin offs for technology transfer purposes, is an entirely new phenomenon.

From the organizational life cycle theory, at the beginning, any business starts at a inception stage, then moves to a formative stage, after that prepares for expansion and fight for national market share [4]. In conclusion of successful nation-wide growth, the company moves on to a stabilization stage. It can be locked in for years at this stage provided that there is a demand for its products. It is very closely related to government of the Republic of Indonesia has projected to make Electric Vehicle (EV) with high quality and ready for mass production [5]. At this phase, research and development (R&D) of MOLINA consortium team UNS are developing the mini manufacturing plant of 10 kWh Li-ion batteries based on LiFePO4 cathode material. Lithium-ion (Li-ion) is one of the types of rechargeable batteries [6].

This type of battery is widely used in consumer electronics as in [7], [8]. Next, it is being adapted for industrial applications to be used in the automotive industry as a source of power for hybrid electric vehicles [7]. Sebelas Maret University with technology equipment owned, creating a technology that was developed in the prototype battery Li-ion batteries based on LiFePO4 nanoparticles used for the application of the SmarT EV.2 [9], [10]. Nanoparticles or chemical spray technology in the development of lithium ion batteries was shown to increase the energy density batteries [11]. The strategy is carried out by manipulating the size of the nano-scale, electrode shape, and also the electrode plate configuration. Optimization will be carried out to design a battery with the ability to release high electrical energy without any loss of power. In the end it is desirable to obtain the lithium ion battery with high energy density [12].

The battery became popular due to its characteristics of portable, rechargeable, lightweight, eco-friendly, slow loss of charge when not in use, has great power over, and others [6], [7]. Moreover, Li-ion battery has no memory effect,

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which means that the charging process only adds energy storage. In Indonesia, there is only one national battery plant ready to produce batteries for EV needs, which is PT. Nipress Tbk that has a production capacity of 6 units of batteries per-day [6].

In an effort to market the battery to consumers, is a must to get a model that fits the commercialization of the above cases. Based on previous research derived conclusion that is a spin-off best way for the start-up company in Sebelas Maret University [13]. The spin-off is a company that exploits a university or research intellectual property that is characterized by the maturity of a technology. An academic spin-off is an enterprise of which the business activity is founded on a technological development or innovative concept developed at the university. The economic scale of this company must be small. In each of these regions and more specifically around each of the local research organizations, we analyzed which financial resources were available for (potential) spin offs and in which stage of the spin-off process these resources were used. In the invention phase, we find without exception, that research grants to the research organizations (universities, public research laboratories and embedded corporate laboratories) play a very important role.

From previous research has been developed a feasibility study of mini manufacturing plant for battery 10 kWh in accordance with the financial analysis and SWOT analysis. The result shows that the mini manufacturing plant is feasible from the value of NPV. The rate of IRR and WACC shows the mini manufacturing plant project required additional loans with lower than IRR [14].

In building a new company have three basic problems, they are the financing, sizing and timing of the project [15]. In the changing world, timing can be a remarkable issue when the outcomes of projects are considered. Correct timing can be assumed to be some meaning for successful operations, and often a certain action is possible only during a given period.

This model develops a framework to determine the timing problems with using the model approach used to launch spin off company. Correct timing can be assumed to be some meaning for successful operations, and often a certain action is possible only during a given period. In addition to resolve he problem, this paper also analyzes the theory of organizational life cycle, Technology Readiness Level (TRLs) and Demand Readiness Level (DRLs) evaluation.

II. Research Method

The subject of this study is the mini manufacturing plant of 10 kWh Li-ion batteries based on LiFePO4 cathode material. The first step in this research is to characterize the battery business process maps. Business process map is a diagram that clearly identifies the steps needed to complete a process. This map gives a description of how the process is done [16].

Fig. 1 Business Process Map Making Lithium Battery

Manufacture of lithium batteries made by following the flow in Figure 1. Battery manufacturing process includes four steps: (1) preparation of electrodes, (2) cell assembly, (3) sealing the container, and (4) test battery. In this study, LiFePO4 material will be used as an electrode material preparation.

The next step is to evaluate the value of TRLs and DRLs. There is much of value in Paun's approach [17]. In defining DRL's, Paun has attempted to create market entities in an identical mechanism to those relating to technology. However, unlike the technology axis, innovation development in readiness for the market comprises components, that although sometimes milestones, may not be necessarily passed in a similar chronological manner. Both TRL's and DRL's do however, share the same important characteristic, in that the extent to which their components are satisfied increases the chances of commercial success for any particular innovation. Combining the components of demand readiness into a scalar number would permit interpretation equivalent to that which can be drawn from TRL's. This makes the market readiness approach more meaningful and practicable as a monitoring and control tool in business, and particularly valuable in terms of the assessment of risk [18].

Once the requirements have been met DRLs TRLs and then the next step is to do Intellectual Property (IP) protecting. IP protection is very important because there are potential financial gains for both the inventor for protecting intellectual property that is licensed by an outside company. A company will be less likely to enter into negotiations if the property has no protection [19]. Filed a patent for it, but the patent procedures are not discussed in depth in this paper.

The next step in this research is to characterize the life cycle of the company. At the beginning, any business starts at a inception stage, then moves to a formative stage, after that prepares for expansion and fight for national market share.

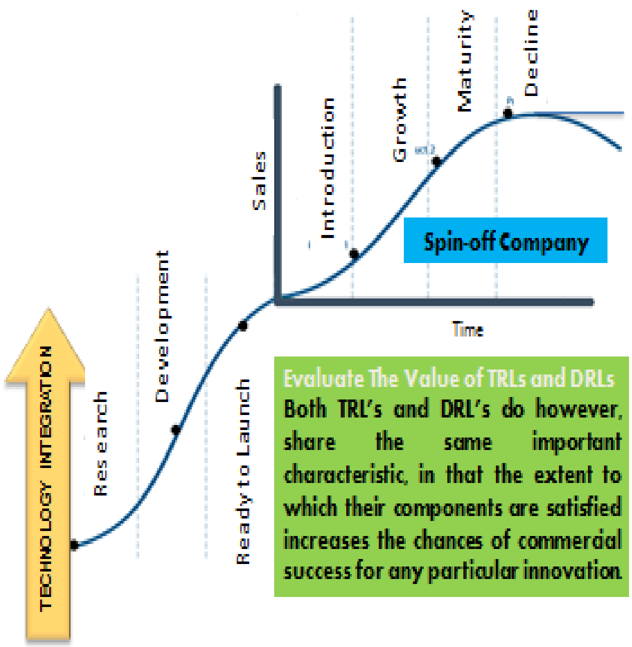

Fig. 2 Problem Identification

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After passing through the Research and Development process, the types of companies that developed is a spin-off company. This study will be calculated optimal time in doing a spin-off company start up.

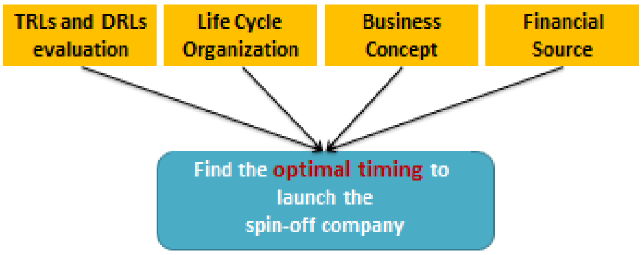

Fig. 3 Research Approach

Capital investment studies can be divided into normative, investment process, and empirical studies [20]. This study is mainly normative [21] and it considers the optimal timing question of a single project. The objects of the study and the background of the researcher naturally affect the choice of research methods and approaches [22] [23]. An individual researcher has to make his choice between different possible alternatives. It is the present author's personal view that the most essential characteristics in scientific reasoning are contribution, invariance and objectivity.

When a single capital investment is planned, there are three basic problems: the financing, sizing and timing of the project. In the changing world, timing can be a remarkable issue when the outcomes of projects are considered. Correct timing can be assumed to be some meaning for successful operations, and often a certain action is possible only during a given period. The research problem is how to find the optimal timing for a capacity expansion project.

III. Result And Discussion

A. *TRLs and DRLs*

Regarding the valuation of the TRLs and DRLs will be as shown in Table 1. TRL scale allowed the identification of various asymmetries between the actors and thus suggested the introduction of various reductions or compensation. Through this contribution, we proposed a new reference system for better addressing the Market Pull approach while doing technology transfer and technological innovation. The DLR scale could also be the object of the same dynamic exchanges and analysis that the TRL scale induced among the academics or practitioner communities. The aim is that this new tool for a hybridized approach will significantly improve the innovation and practices trough a better understanding of the different factors and staging allowing the agreements signatures to create value. With a better understanding and control of the hybridization strategy between Technology Push and Market Pull approaches the innovation system tends to evolve towards a better compatibility with the social and environmental requirements inevitably market pull driven as in the case of eco-innovation. Based on an assessment, the value obtained DRLs is 3 and the value of TRLs is 4, so when added together have a total value is 7. The DRLs worth 3, it has been developed for the identification of the expected functionalities for new product and the TLRs worth 4, it has been developed for laboratory demonstration.

TABLE I
Technology readiness level and Demand Readiness Level

DRL Level	Description Demand Readiness Level	Description Technology Readiness Level	TRL Level
1	Occurrence of feeling "something is missing"	Market Certification and Sales Authorisation	9
2	Identification of specific need	Product industrialization	8
3	Identification of the expected functionalities for new product/service	Industrial Prototype	7
4	Quantification of expected functionalities	Field demonstration of whole system	6
5	Identification of system capabilities	Technology Development	5
6	Translation of the expected functionalities into needed capabilities to build the response	Laboratory Demonstration	4
7	Definition of the necessary and sufficient competencies and resources	With research to prove feasibility	3
8	Identification of the Experts possessing the competencies	Applied Research	2
9	Building the adapted answer to the expressed need in the market	Fundamental research	1

So it can be said that the lithium ion battery has not met the requirements of DRLs and TRLs and required more effort from stakeholders so that the product can be commercialized soon.

B. *Transferring Technology By Spinning Off*

A first step in the analysis of the spin-off process is to position "research-based spin-offs" both among other types of high tech startups and among other vehicles for technology transfer. The literature on high tech firms offers an interesting insight regarding the role of technical uncertainty: the high tech startups can be classified on a continuum ranging from pure innovators (developing their own technology) to pure imitators (using technologies) [24].

Second, the innovation literature points to the importance of the complementary assets – manufacturing, distribution, complementary technologies, sales and service, etc.-- or the situation on the downstream market as a predictor of the chances which a start-up versus an incumbent firm has to commercialize an invention. In other words, that innovators need a number of specialized complementary assets in order to capture value from the technology [25]. When a totally new market has to be created, market uncertainty is very high and incumbent firms are unlikely to monopolize the downstream value chain needed to penetrate the market.

Hence, at this end of the continuum startups make a good chance to realize economic profits. At the other end of the continuum, where market uncertainty is quite low, the value chain is normally controlled by a number of incumbents, which make it impossible for new startups to realize economic profits. Figure 4 describe about structures these insights into a two-dimensional figure in which four quadrants can be distinguished. Each quadrant represents a "pure type", pointing to typical characteristics regarding market and technical uncertainty.

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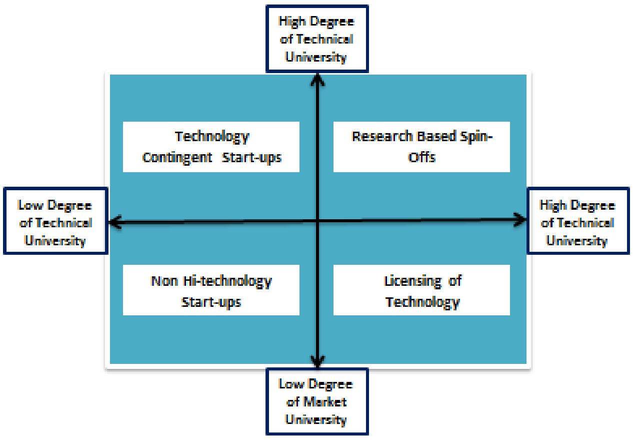

Fig. 4 Determinants of commercialization

In figure 5 is explained about some of the things that must be built into the launch a spin-off company of which is the operational environment, core entrepreneurial action and supportive structure.

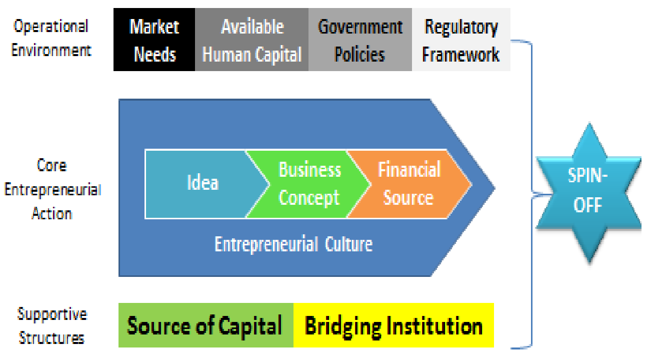

Fig. 5 Spin-off Company Structure

C. *Optimal Timing to Launch Spin-off Company*

The timing of capital investments often has a great influence on the firm's profitability. This problem is common in the mini manufacturing plant of 10 kWh Li-ion batteries capacity additions. Several things, such as the firm's competitive position, possibilities to finance projects, and costs of projects all have effects on the optimal solution. Despite the complexity, the situation can be simplified, and closer analysis can be made about the parameters that really matter. Timo Karri's model focused on the number and cost of production [31].

Technological change and life cycles have their own roles in medium and long run decisions [26]. Large investments are naturally extremely risky, and economies of scale often have a central impact on these decisions. Typically the size of equipments increases year after year. When the capital investment is significant as compared to the firm's size, knowing the best timing for the expansion is valuable [27]. It is important to notice that costs can be direct and variable, direct and fixed, indirect and variable or indirect and fixed at the same time [28] [29]. It also made a cost classification of flexible and committed costs [30]. This kind of optimization emphasizes the role of production capacity level even more than the traditional categorizations.

Timo Karri models derived from a mathematical model which has the purpose to obtain the optimum time used [31] are as follows:

$$z = (a-c)q_0 + b + v$$

$$t_{opt} = \frac{q_1}{k}\left[\frac{z}{v} - \sqrt{(\frac{z}{v})^2 - (\frac{2q_0}{q_1} + 1)}\right] \tag{1}$$

Where

t_{opt} = optimal expansion time [years]
q_0 = capacity of the old equipment [unit/year]
a = variable unit costs of the old equipment [currency unit/unit]
b = fixed costs of the old equipment [currency unit/year]
q_1 = capacity of the new equipment [unit/year]
c = variable unit costs of the new equipment [currency unit/unit]
v = fixed costs of the new equipment [currency unit/year]
k = arithmetical growth rate of demand [unit/year/year]

There are several assumptions behind the standard cost-volume-profit model [32] [33]. Technological progress and economies of scale mean increasing equipment size and decreasing production costs, the variable and fixed costs of the equipment and their capacity can be determined accurately enough, certain equipment sizes determine the firm's capacity options and give the possibility to find the exact solution for the suitable expansion time and a limited planning horizon is used due to demand and technology unpredictability in the long run.

From these models with variable unit costs of the old equipment (a) = USD 773,6 / unit , variable unit costs of the new equipment (c) = USD 940 / unit, the arithmetical growth rate of demand (k) = 35 units/year, the capacity of the old equipment (q_0) = 50 units/year, the capacity of the new equipment ($q1$) = 100 units/year, fixed costs of the old equipment (b) = USD 250.000/year, and fixed costs of the new equipment (v) = USD 350.000/year. A static and deterministic environment is also assumed, e.g. the model works with conditions of constant technology and no uncertainty. Changes of environment can be incorporated into the model with sensitivity analysis [34].

From the data obtained z value of USD 591.680, in order to obtain top is 3.12 years. So the mini manufacturing plant of 10 kWh Li-ion batteries require planning time than now to expand when viewed in terms of Unit cost-A Cost Advantage with Timing. A solution for the optimal timing of capacity change, when unit costs are minimized in a planning period, was presented above. Naturally there are some simplification that reduces the suitability of the model to practice and give reason for criticism. The model does not include the inventory possibility, but on the other hand it can be said that an inventory gives only short-term flexibility to the firm, and does not solve long term capacity problems. There are also many situations where a firm has no inventory at all in practice.

It is also true that the optimal expansion time can be earlier than the model shows if the new equipment can be put into full production in a shorter time, i.e. part or all of the adjustment is done with the uneconomical old equipment. This is because in modern technology low unit

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costs usually require high capacity utilization rates. These kinds of models are numerical rather than analytical. Of course more complicated solutions give possibilities for further research. It is also clear that more calculations in different situations of capacity changes are needed to verify the applicability of the model in practice. Capacity cutting was only briefly considered and it offers possibilities for further analysis.

The main point is how to find suitable capacity adaption time when all production can be sold. When the capacity of the new equipment and the growth rate of demand are given, then in fact the planning period, i.e. the period when the new equipment is in full use, is fixed.

D. Managerial Implications

The benefits of this research for the researcher is able to determine the benchmark improvements in technology development. While the benefits of the management team with the spin-off that this research can have a reference investment and how long it takes is well worth the investment.

IV. CONCLUSION

This paper analyzes the model of time and provide a recommended framework to launch a spin-off company qualitatively. A model were analyzed in terms of the concept of organizational life cycle, Technology Readiness Levels (TRLs) and Demand Readiness Level (DRLs) to determine the optimal time for launch a spin-off company. In a series of development models In an effort to shorten the time of the establishment of spin-off companies, can be done by increasing the value of TRLs-DRLs achievement and extra effort required in the construction of the company's production capacity.

Suggestions for further research will be more about analyzing the timing model predictions quantitatively. It's needed to mix in details by Timo Karri optimal timing model and get the optimal time used to launch a spin-off company that evaluate by TRLs, DRLs and calculating correctly on aspects of how the change in demand that occurs that is associated with the life cycle organization and require any investment in expanding capacity for the company.

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