

Analysis of Technology Product Commercialization Readiness Using the Model of Technology Commercialization Readiness Level: A Case Study at the National Laboratory for Starch Technology with Fermented Tapioca Production Technology Products

Aton Yulianto¹, Sigit Purwanto¹, Palupi Tri Widiyanti¹, Ferdy Pradana¹
¹(Agency for the Assessment and Application of Technology –
National Laboratory for Starch Technology, Indonesia)

Abstract: The low product utilization from research, development, and engineering (R&D) in industrial sector indicates that the successful application of technology products is not only determined by technical factors of technology, but also the readiness of R&D institutions and universities in commercializing the technology. An effort to identify the readiness to use technology products is appraised by an instrument for evaluating the commercialization of technology. This study assesses twelve qualification factors consisting of commercialization experience, general management, functional management, technical sales and support, liquidity and access to capital, competitive position, customer knowledge, customer commitment, affordability, intellectual properties management, sales forecasts, and forecast uncertainty. As a case study, Technology Commercialization Readiness Level (TCRL) is applied to B2TP with the results of R&D in fermented tapioca products on a fiscal year of 2018. The result shows that TCRL from B2TP had a total value of 5.75. This shows that a comprehensive improvement effort is needed especially at the concept, system and technology stages.

Keywords: R&D and engineering, technology products, qualification factors, technology commercialization.

I. INTRODUCTION

Commercialization of research products in research, development, and engineering (R&D) institutions in Indonesia is quite low compared to other countries, even in South-East Asia region. Based on data released by the Global Innovation Index (GII) in 2019, Indonesia ranks 85 out of 129 rated countries. In South-East Asia, Indonesia has the lowest rank, only above the rank of Cambodia, while Singapore, Malaysia, Vietnam, Thailand, Philippines and Brunei Darussalam has a rank of 8, 35, 42, 43, 54, 71, respectively[1]. The assessment indicates the average value of the innovation input, and output index consisting of seven main pillars in a country, including institutions, human resources and research, infrastructure, market and business reliability, outputs of science and technology, and creativity [2].

Commercialization of R&D products or the application of technology is a process of technology transfer from R&D institutions to industries for mass production process that are then marketed, and obtains profits both for the producing industry and the technology owner of the R&D products. The low level of commercialization is identified by the large number of R&D products that stop only at scientific reports or journals and are not continued to the actual conditions applied in the field. Moreover, the information on the success level of the application of R&D products is limited to the technological readiness level (TRL) and innovation readiness level (IRL), where the measurement have been determined through a regulation of Minister of Research, Technology and Higher Education Number 46/2016 and Number 29/2019[3] [4].

In the field of engineering management, prescriptive analysis has been widely used to assess the progress and success of engineering technology efforts. The prescriptive analysis is a recommendation analysis based on optimization methods and algorithm simulation about some needs to be done to achieve the desired objectives. However, this type of prescriptive analysis has two main challenges, namely personal subjectivity and belief in data estimation. In this article, a prescriptive analysis that focuses on the technology commercialization readiness level (TCRL) or business readiness level (BRL) is used. TCRL considers a probabilistic approach in indicating business risks to institutions that will implement the R&D products.

TCRL measurement is intended to indicate business risks for R&D entities that will implement or commercialize their R&D products/technology. The business risk is measured as a value that is then be used by R&D institutions to improve the performance of institution itself in accelerating the downstream process of R&D products or technology that are commercialized. This article aims to provide an alternative method of determining the success of the commercialization of R&D products through the measurement of TCRL that is

expected to be a solution for R&D and engineering institutions, universities and government in increasing downstream process of produced technology (R&D products) to industry (technological innovation).

II. LITERATURE REVIEW

The readiness level is one of the keys to success to ensure that a performance is consistently and correctly implemented. It includes a series of performance metrics that provides feedback on current performance and anticipates future success [5]. To increase the success of commercialization of technology products, the readiness of R&D institutions that have the task of commercializing the technology products needs to be known. In general, the commercialization of technology products must have a concrete strategy in every implementation to reduce the risk of failure due to the institution's inadequacy in commercializing the products.

In addition to technical factors, other important factors to consider are non-technical factors that have been mentioned previously as the main pillars in the GII assessment. The complexity of the challenges in improving the performance of these factors is fundamental to be considered. Therefore, a combination of available readiness levels, such as manufacturing, system, and other readiness levels is needed, so that the commercialization of engineering products can be achieved [2]. TCRL is the basis of business considerations that have a high probability of achieving the success or failure of an R&D institute in commercializing technology/products.

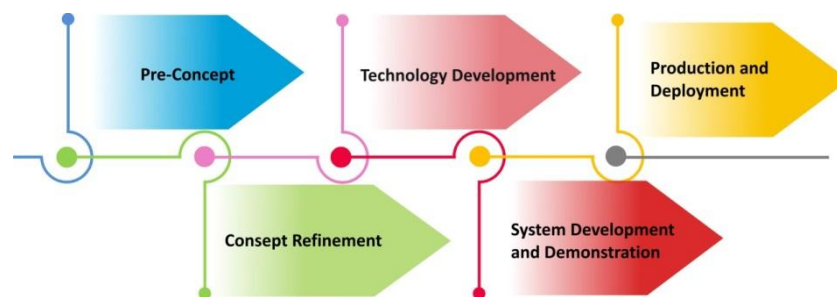


Fig.1 Stages of Commercialization of Technology Products
(concept; concept improvement; technology development; system development and demonstration;
production and dissemination)

National Laboratory for Starch Technology (B2TP) has developed the concept of Technology Commercialization Readiness Level that refers to the BRL assessment method issued by Northrop Grumman Corporation in 2011[6]. The level of commercialization readiness has 12 (twelve) qualification factors that are divided into five parts of the commercialization stage (Fig.1) namely Concepts, Concept Improvement, Technology Development, System Development and Demonstration, and Production and Dissemination. Each of these qualification factors has certain assessment criteria that indicate the achievement of R&D institutions and technology-producing tertiary institutions.

Qualification-1: experience of commercialization, is the level of management team that has successful experience in commercializing (applying/utilizing technology to produce) new products. **Qualification-2:** general management, is the level of the R&D institution that has officials or general management expertise. **Qualification-3:** functional management, is the level of the R&D institution that has expertise/ employees in functional management (e.g.: R&D, production, finance, marketing, and sales). **Qualification-4:** sales and technical support, is the level where the R&D institution provides technical sales support to potential customers before sales and technical support training, guarantees, and improve service to customer after-sales. **Qualification-5:** liquidity and access to capital, is the level where the R&D institution has access to sufficient capital/budget to add the product value at a higher TRL to increase the TCRL value and increase business; the amount of backlog revenue is defined as the future revenue that is certain from the contract that was signed. **Qualification-6:** competitive position, is the degree to which competition/markets threaten product viability. The competition in question must consider not only the direct competitor products, but also other very different products of customer choice. **Qualification-7:** customer knowledge, is the level where the R&D institution knows its potential customer, customer desires and all customer needs for their products. **Qualification-8:** customer commitment, is the level where the customer is committed to spending enough resources to increase the value of a higher TRL. The customer is an organization with the authority and funding to buy several technology products. Organizations/institutions/companies that have a research mission and investors are not customer. **Qualification-9:** affordability, is the level where the product is affordable by the customer, in terms

of research, acquisition, distribution/distribution of operations and its supporters, and disposal costs. **Qualification-10:** intellectual property management, is the level at which the R&D institution can protect its intellectual rights through the use of patents, trademarks, trade secrets, licensing agreements, or open agreements. **Qualification-11:** sales forecast, is the level where the expected annual sales of the product exceeds the total expected investment. **Qualification-12:** uncertainty forecast, is the level of uncertainty at which actual sales will meet or exceed sales estimates.

TCRL measurement is performed by processing numbers (spreadsheets) based on several achievement questions for each qualification factor and displays achievements on each qualification factor. Each qualification factor has 10 indicators of success that have a level scale of 1-10.

III. METHODOLOGY

TCRL measurement is a method developed from BRL assessment issued by Northrop Grumman Corporation in 2011. It is carried out independently by an R&D institute producing technology products that are ready to be commercialized. In this article, TCRL assessment is conducted in a case study in B2TP with an R&D (technology) product of fermented tapioca. The research approach used is qualitative and quantitative data and data collected through questionnaires, interviews and literature studies. The aim is to find out the status of the institution, the mapping process and reduce the risk of failure of R&D institutions and universities in commercializing the R&D results.

The process of measuring the commercialization readiness is the main data obtained from the head of the program that is responsible for the results of the technology products and the related structural officials. Qualification factors of the results of interviews with respondents include the experience of commercializing technology products, managerial skills, marketing and access to capital, competitors of similar products and intellectual property rights. Data analysis is conducted prescriptively through four stages, namely Stage-1: discussion with the Head of office to determine technology products that are ready to be commercialized; Stage-2: identification of qualification factors for the readiness of the technology commercialization of data from the questionnaire results and interviews with respondents (head of the R&D program); Stage-3: compiling TCRL measurements based on a number processing (spreadsheet); and Stage-4: preparing recommendations for the readiness of commercialization of technology products.

IV. RESULTS AND DISCUSSION

A. Result of independent TCRL assessment

B2TP has produced a variety of technology products, but the assessment of TCRL is specifically about fermented tapioca. This technology product is the result of a review of the 2018 fiscal year.

The result of the assessment of technology commercialization readiness in the production of fermented tapioca can be seen in Fig.2. The lowest achievement level is 2 in the qualification factor of sales forecast (factor 11), that is the rate at which the expected annual sales of the product exceed the expected total investment. At the achievement level of 4, there is affordability factor (factor 9), that indicates the level at which the product is affordable by customers, in terms of research, acquisition, distribution/distribution of operations and supporters, and disposal costs (disposal) cost). As for the level achievement of 5, there are 2 (two) qualification factors, namely: the competitive position (factor 6), that is the degree to which competition/markets threaten product viability, and the intellectual property management (factor 10), i.e. the level at which the institution/implementing unit of R&D can protect its intellectual property rights (IPR) through the use of patents, trademarks, trade secrets, license agreement, or open agreement.

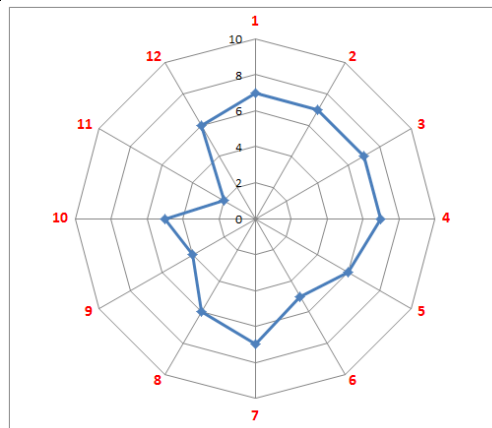


Fig.2 Graph of Independent Assessment Results of TCRL of Fermented Tapioca

At the level of attainment of 6, there are 3 (three) qualification factors. First factor is liquidity and access to capital (factor 5), that identify the availability of cash to support business activities, where the institution/unit of research and development has access to sufficient capital to add the product value at a higher TRL and to increase the TCRL value. Second factor is the customer commitment (factor 8), that mentions the level of the customer commitment to spending enough resources to increase the value of the product at a higher TRL; the customer is an organization/institution/company with the authority and funding to buy some products/technologies, but not that of have a research mission, and also, investors are not customers. Third factor is the uncertainty forecast (factor 12), that shows the degree of uncertainty at which actual sales will meet or exceed sales estimates.

At the achievement level of 7, there are 5 (five) qualification factors. First, the experience of commercialization (factor 1) suggests the level of management team that has successful experience in commercializing (applying/utilizing technology to produce) new products. Second, the general management (factor 2) refers to the level of the R&D unit that has officials/general management expertise. Third, the functional management (factor 3) notes the level at which the R&D unit that has expertise/employees in functional management (R&D, production (implementing technology services), finance, marketing, and sales). Fourth, the sales factors and technical support (factor 4) shows the level at which R&D institutions/units that can provide technical sales support to potential customers before sales, and provide technical support training, guarantees, and improve service to customer after-sales. Fifth, the customer knowledge (factor 7) indicates the knowledge level of the R&D institution of its potential customers, customer applications, and all customer needs for their products. The results of the assessment of fermented tapioca products can also be shown in Table 1.

B. Analysis and Follow-Up Assessment Results

Table 1. Results of Fermented Tapioca Self Assessment using TCRL

Pre-Concept	Concept Refinement				Technology Development		System Development and Demonstration	Production and Deployment	Ops & Support	
	1	2	3	4	Component	System				
TCRL	1	2	3	4	5	6	7	8	9	10
FACTOR 1										
FACTOR 2										
FACTOR 3										
FACTOR 4										
FACTOR 5										
FACTOR 6										
FACTOR 7										
FACTOR 8										
FACTOR 9										
FACTOR 10										
FACTOR 11										
FACTOR 12										

Based on these measurements, the technology product measured has a total value of 5.75 (in the range of values 5 to 6). From table-1, it is known that the qualification factors for the level of technology commercialization readiness are mostly at the level of readiness 6 and 7. This shows that the R&D institution is at the stage of technological development. Therefore, it is not quite safe to commercialize the product. The R&D institution as technology producer needs to make efforts to increase the level of technology commercialization readiness to a range of value above 9.0, i.e. at the production and dissemination stage to avoid the risks of failure in the application of technology.

The description of each qualification factor indicates the need of efforts to increase the level of sales forecast, affordability, competitive position, and intellectual property management that are very low in readiness. Some of the efforts that can be made include improving the efficiency of investment costs, production costs, commercial costs, and other costs, exploring the market potential and the advantages of fermented tapioca product so that the cost of goods sold can be determined to achieve an annual sales ratio to a minimum total investment of 2.5:1 in 5 years. Preparation of strategies needs to be performed so that the cost of acquisition (availability of raw material supply and guaranteed absorption of products in the market) and the cost of distribution of technology product that will be commercialized are lower than other basic costs and the payback period is less than 3 years. This can be done by facilitating cooperation in the supply of raw materials with the providers to obtain the stable price of raw materials, producing fermented tapioca product according to market needs (the broad spectrum of use and starch prices have the opportunity to produce starch with certain specifications according to market needs) to achieve the high selling price (high added value), and does not having to build a new factory but grafting fermented technology in existing factories. Furthermore, it is important to yields the good and stable quality of fermented tapioca products through the use of modern equipment for washing raw materials and controlled fermentation technology. Then, the institution shall allocate an adequate budget so that it can maintain and protect IPR and other cooperation agreements.

Efforts to improve liquidity and access to capital, customer commitment, and uncertainty forecast can be executed by improving technology services, especially cooperation in the application of technology and laboratory testing, establishing communication with an institution that have the task to commercialize technology products to invest when potential third partners is willing to do operational cooperation with B2TP. In addition, it is needed to increasing the trust of partners and prospective partners by improving the quality of services, activating a communication forum that has been built, optimizing the utilization of the Business Information Technology and Techno-park as a means of promotion and meetings with prospective partners. Furthermore, establishing communication with the user industries and industry associations is important to obtain an accountably data related to market volume and opportunities to make purchase commitments.

V. CONCLUSION AND RECOMMENDATIONS

The assessment of TCRL in R&D institution or university is a means to determine the level of readiness in commercializing technology products. Based on the measurement results, the higher score of TCRL, the easier R&D institutions and universities will be to carry out commercialization of technology products with fewer obstacles. Conversely, the R&D institutions with lower TCRL score should improve the achievements level of TCRL beforehand.

Therefore, determination of TCRL can be used to predict the risk of failure in the commercialization of technology, to avoid R&D institutions and universities from loss, as a result of their failure to accomplish technology commercialization. In case of TCRL implemented in B2TP with a technology product of fermented tapioca, the assessment result shows that the score of TCRL has a total value of 5.75. It means that a comprehensive improvement effort is needed, especially at the conceptual, development stages system and technology.

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