REASSEMBLING TECHNOLOGY TRANSFER IN INDONESIA

Syafrizal Maludin[1]
syafrizal_maludin@yahoo.com

Rizal Syarief
rsyarief@yahoo.com

Amzul Rifin
amzul_rifin@yahoo.com

Nurual Taufiqu Rochman
ufiq2000@yahoo.com

ABSTRACT

This article aims to provide a dynamic picture of the technology transfer process in public research institutions in Indonesia that has been updated by establishing the National Research and Innovation Agency in August 2021. This body is directly under the President of the Republic of Indonesia based on Presidential Regulation number 78 of 2021. During the research period, there was a change in the landscape of technology transfer actors. Some of these changes are in line with the results of the analysis, namely increasing the role of GFRI and research and development agencies under the ministry. This change is referred to as technology transfer reassembly. The arrangement of technology transfer leads to a new form. The research was initiated in October 2017 using the AHP to determine the best institutional arrangement for integrating research. The AHP results show the rank of institutional arrangements from highest to lowest as Government Funded Research Institutes (GFRI) (0.27833), a research division under the Ministerial Office (0.24890), universities (0.17966), private R&D (0.13589) and foreign agencies (0.07214). Government Funded Research Institutes are the top choice of experts for having a significant role in the technology transfer process. The core function of GFRI in the technology transfer system is to plan, conduct and develop technology and they have contributed significantly to the policy-making process by providing information and policy recommendations. This research enriched the application of the recommendations by establishing the National Research and Innovation Agency as the most influential actor in building a national technology transfer system.

[1] Corresponding Author
Acknowledgement: This paper has been developed by the first author in his Doctoral dissertation funded by the Ministry of Research Education and Higher Education of The Republic of Indonesia decree number 35/M/Kp/IX/2014

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v13i3.846

Keywords: Analytic Hierarchy Process; government technology transfer; presidential regulation number 78 of 2021; public research institutes; science technology park; technology business incubator; National Research and Innovation Agency (NRIA).

1. Introduction

Technology innovation is increasingly expected to underpin economic growth (Bercovitz & Feldmann, 2006; Blohmke, 2014; Costantini & Liberati, 2014), but expectations are far from being met. In addition, the high cost of research, the maintenance costs of patents, and the inability to create new technology-driven companies make technology transfer a necessity.

The method of technology transfer occurs through the dynamics of technological developments in certain industrial sectors. Technological developments, for example, are growing faster in the information technology, telecommunications and banking sectors than in the mineral and textile technology sectors. On the other hand, the planned changes are made by the most influential parties when it comes to technology transfer. This study focuses on technology transfer to government research institutions so that the re-assembly that occurs is initiated by the government through incentives, regulations and reorganization of institutional arrangements.

People expect research institutes to provide scientific solutions to a variety of issues, from food to energy to pharmacy and manufacturing. Incentives and increased budgets had been set by the government to increase both the quality and quantity of research. The key objective in developing science and technology is strengthening national competitiveness (Delgado et al., 2012; Slaughter & Rhoades, 1996). Universities and government R&D institutions have produced many research results that can significantly reduce dependence on food imports, such as research of soybeans and wheat which can be successfully produced on a commercial scale. An application of this research called fortification, which was an effort to eliminate stunting in Indonesia led by President Joko Widodo in 2018, can be achieved by the country; however, other considerations for wheat, soybeans, and enhancement materials are still provided by imports.

The number of patents has been increased in line with increasing socialization and training to protect intellectual property through training and workshops on intellectual property (IP) in areas like patent drafting. These have been conducted by IP consultants, universities, research institutes, as well as the Ministry of Law and Legislation of the Republic of Indonesia.

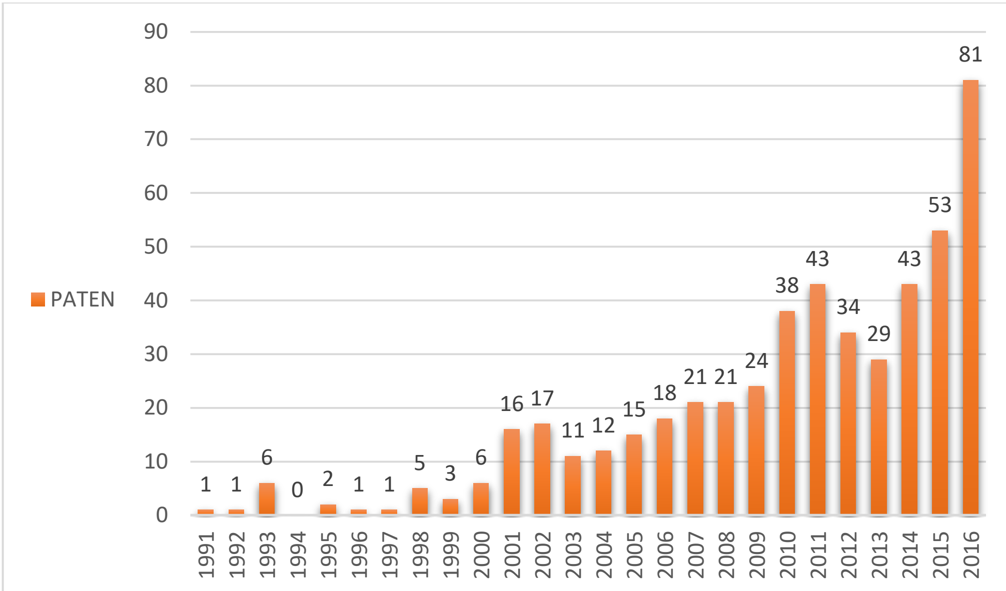

Figure 1 Patents of the Indonesian Institute of Sciences 1991-2016 published in 2017 by Pusat Inovasi LIPI (modified)

It can be inferred that industrial development is still based on their principal invention to be applied to their product. Researchers were encouraged to submit their research under patent protection and disseminate it to a potential private sector user. On the other side, in the macro view, the growing number of patents has not increased relative to the number of foreign patents. This could indicate that industrial development still relies on their principal patent from other countries while the objective of local research institutes is to register patents. Researchers have been encouraged to submit their research protected by the patent regime and disseminate it to potential users from the private sector.

It is worth understanding the difference between tools and objectives in this appropriability regime case, which is similar to the difference between justice and law (Horvath & Kelsen, 1957). Justice should be the objective of the law. The law as the objective of justice is rather inept. Therefore, a patent is a tool to protect achievement in the intellectual field. When the patent becomes the objective, it will lead to a maintenance fee that should be paid by the taxpayer.

Since the main objective of this appropriability regime is to protect the owner of the scholarly outcome and benefit the user, the number of patents achieved should not be the target. When the outcome of the research, as the single apparatus of one product, was protected, most potential users were reluctant to utilize it. The worst cases have occurred in a number of state universities and public research institutions that have paid the maintenance fees for unutilized patents.

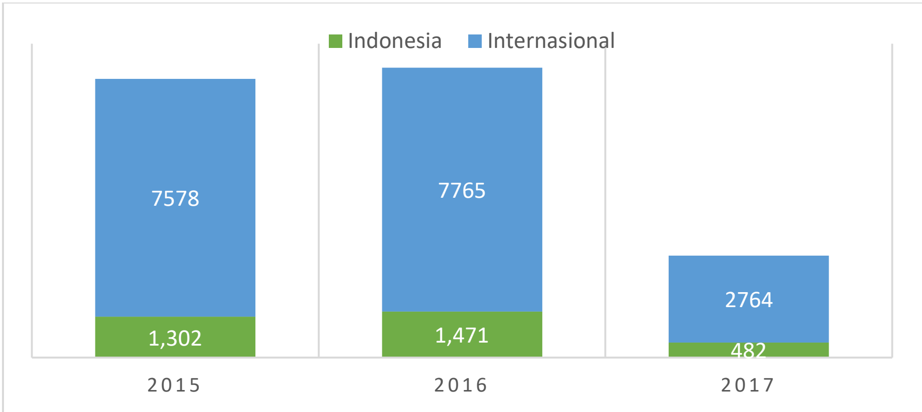

Figure 2 Local and foreign patents in Indonesia 2015- mid 2017 published in 2017 by Direktorat Jenderal Hak Kekayaan Intelektual Republik Indonesia, [2]

Most international patents relate to products from multinational companies (MNC). However, opportunities for local inventors are still available if MNC are willing to collaborate with a local research institute. The most generic to the most advanced technology could be produced by a local inventor. In an interview with one of the MNC production managers about the innovation process, the manager discussed the possibility of utilizing a patent from a local inventor if it was supported with relevant documents that ensure the safety of the product. Another important issue was the price of the license, which should be cheaper than the patent provided by a foreign inventor. The process of utilizing a patent from overseas is not as complicated as contacting the researcher to solve problems within the production process. The quickest way is to buy a cheap invention abroad, which leads to a larger gap between industry (technology-user) and public research (technology-provider). This research investigated the idea of policymakers linking research output to industry using the Analytical Hierarchy Process (AHP).

2. Literature review

2.1 Technology transfer system at the Public Research Institute

Modifications to the study of dissemination, transfer and technological innovation are adapted based on the orientation and scale of the research. This linear flow also grows with changes in the nature of the technology and its users. When discussing a technology transfer policy, there are two kinds of technology transfer. The first is called American Centrist and refers to technological developments that are carried out primarily on the basis of private R&D that is influenced by the demand of users of technological products. On the other hand, Mazzucato (2012) shows the significant role of the federal government's R&D in the development and transfer of technology in areas such as local area network applications and touch screen technology. However, the success of the use of technology in America is tied to the users of the business. The second kind is called

[2] Directorate General of Intellectual Property of The Republic of Indonesia. It is commonly called the Indonesian Patent Office

Scandinavian centrist where the government plays the predominant role in the development of innovation and technology transfer.

Hassan and Jamaluddin (2015)) divide the technology transfer processes into ten categories around the world, as follows:

1. Calantone model (Calantone et al. 1990)

This model is composed of 9 elements, namely:

- Environmental considerations that impact all stages of the technology transfer process.
- Technology transfer actors composed of technology providers, suppliers, NGOs, and governments.
- Structure, which is a component that describes the relationships, mechanisms and communication between the actors involved in the technology transfer process. The lines of communication are built through political, economic and business relationships.
- A process, which is an element that involves negotiations between technology suppliers and users impacted by communication channels consisting of technology selection, partners and technology transfer modes.
- A technology transfer function that involves the implementation, assessment and oversight of technology transfer projects.
- The background of the two actors of technology transfer that affect the success of the technology transfer process.
- Political factors which include the political system, political structure and the strength of the relationship between the state and NGOs.
- Economic factors, namely the level of economic growth and stability that affect the speed of industrialization based on technology transfer.
- Cultural factors that influence the successful implementation of the technology transfer program.

2. Simkoko Model (Simkoko, 1992)

An effective technology transfer mechanism is influenced by 7 elements of this model, namely technology transfer, technology users, technology, mechanisms, technology transfer, and technology users' environment, the surrounding environment.

3. Kumar Model (Kumar et al., 1999)

The study examined important elements for industry in order to increase its capacity to use developed country technology. The industrial sector in Indonesia is the object of research which includes the actors involved in the process, transfer method, size, type, standard activity, the nature of ownership, training and capability of the R&D division (RD). Three important factors in technology transfer, which are presented in this study, are dynamic investment, activity and learning capacities.

4. Lin and Berg Model (Lin dan Berg, 2001)

This study highlights the important factors that influence the performance of the technology transfer process abroad in Taiwan. The three actors of technology transfer are the technology transfer environment, the transferor and the beneficiary of the technology transfer (transferor/transferee) and the culture of the country of origin.

5. Malik Model (Malik 2002)

This model involves elements of knowledge, expertise, actors, processes, modes, barriers and opportunities for technology transfer. Broadly speaking, the process of technology transfer is influenced by two factors, namely factors that strengthen and hinder technology transfer.

6. Wang Model (Wang et al., 2004)

This model represents the transfer of knowledge and technology from the leaders of multinational companies with their overseas branches. Transferee and transferor characteristics affect the efficiency of technology transfer. Additionally, a country's economic advantage also influences the characteristics of the technology transfer process.

7. Steenhuis and Bruijn Model (Steenhuis & Buijn, 2005)

This model study was carried out in the civilian aviation industry. This model calls for a balance of needs between the transferor and the transferee.

8. Waroonkun and Stewart Model (Waroonkun & Stewart, 2008)

The model is aimed at strengthening the technology transfer process in developing countries. In this model a business environment consisting of certain techniques, expertise, and capability requirements related to technology transfer needs to be developed to strengthen the technology transfer process in developing countries. The standard methodology is one of the requirements for the effectiveness of the technology transfer process. Moreover, a country's maturity in understanding and applying technology transfer influences its success rate in the technology transfer process.

9. Mohamed Model (Mohamed et al., 2012)

There are four categories that affect successful results in technology transfer including support for technology transfer, environmental infrastructure, and learning capacity.

10. Khabiri Model (Khabiri et al., 2012)

An effective technology transfer mechanism is influenced by seven components of this model as follows: technology transfer, technology users, technology, mechanism, environment of technology transfer, technology users and universal environment.

Technology transfer under this research focuses on the transfer of technology and know-how from technology providers to average users or end users. Intermediary users play a significant role in technology transfer when research results will be useful when combined with other discoveries. An example of this is the invention of the touchscreen layer that cannot be used alone, but must be used in conjunction with other inventions to produce communication devices or other optical devices. Therefore, the invention of an

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v13i3.846

actor technology supplier can be a raw material for comparison of other technology suppliers.

2.2 AHP concept in the field of technology transfer

A Google Scholar search using "AHP" and "Technology Transfer" as the keywords led to 8 relevant articles. Each article has a different research focus and locus.

Table 1
Previous research

#	Author	Article Title
1	Chehrehpak et al., 2012	Select optimal methods for the technology transfer by using the analytic hierarchy process (AHP).
2	Erensal & Albayrak, 2007	Transferring appropriate manufacturing technologies for developing countries.
3	Gerdsri & Kocaoglu, 2007	Applying the Analytic Hierarchy Process (AHP) to build a strategic framework for technology road mapping
4	Kumar et al., 2015b	Benchmarking supply chains by analyzing technology transfer critical barriers using the AHP approach.
5	Lee et al., 2013	Using AHP to determine intangible priority factors for technology transfer adoption.
6	Wang et al., 2009	Changing technology transfer strategies in a non-profit organization - An examination of ITRI.
7	Yazdani et al., 2011	Ranking of technology transfer barriers in developing countries; a case study of Iran's biotechnology industry.

The selection of the articles is based on a similar research cluster. Each article is in the cluster of technology transfer of various technologies. This proves that AHP is pertinent in this cluster. Kumar et al. (2015) employed the AHP in their research to measure the critical factors in technology transfer, including policymakers in international organizations, government officials and environmentalists. This concept led the authors to consider that the decision-maker and manager should be the ones evaluating the appropriateness of technology transfer. This approach fits the needs of managers to anticipate critical factors to achieve efficiency of the technology transfer process.

The AHP was also utilized to develop a strategic framework of technology road mapping (Gerdsri & Kocaoglu, 2007). This roadmap was called ‘technology development envelope’, which translated to a technology transformation that flexibly and dynamically assisted organizations to effectively conduct technology transformation. The decisions that were made were valued by alternatives developed through change management.

Bozeman (2000) employed the Contingent Effectiveness Model (CEM) to measure the effectiveness of the technology transfer process. The objective of this method is similar to the AHP in that it effectively measures criteria in the technology transfer process that include the role of capacity development and the political system. In conjunction with an Indonesian technology transfer system, the political system greatly influences the development of science and technology (ST) and includes the theme of research and the position of high-ranking officials in the budget control over research activities. This used to be a two-way communication where scientists briefed parliament about trends as they relate to current issues. Therefore, technology transfer from a public research institute to users was unfavorable. However, the promised budget increase for ST since 2003 has never happened. Budgets for ST can be very flexible in contrast to budgets for education and health, where changes in budget allocation for research can fluctuate. However, the expectation of ST's contribution to competitiveness is always ranked first, which makes rethinking technology transfer the key question of this research.

Another problem is the flow of the transfer from the technology provider to the user. Experts agree on the egocentric nature of the public research body that has led to unproductive action It is uncommon to see the flow of technology-based-products that were invented in basic research institutes and developed by the applied research agency. Therefore, establishing the NRIA would be better if it exists as a body under the Ministry of Research and Technology before it is applied to a wider scale. However, the classic dilemma occurs when the decision-maker has to make a decision in a limited timeframe.

One of the objectives of the NRIA is to centralize (not synergize) the actor that functions as the technology provider and has new terms such as LITBANGJIRAP[3] for Research – Development – Assessment and Application (RDAA). This policy aims to increase the role of technology to strengthen national competitiveness. It is also supported by establishing an endowment fund, extending the retirement age, decreasing taxes on research activities and establishing the national repository.

3. Public Research Institutes as agents of technology transfer in Indonesia

Taxonomy of technology transfer was developed to represent the agents of technology transfer in Indonesia, which consist of type of technology and transfer, transaction method, classification and characteristics. Technology transfer was also divided by long, short or medium range of time and source of finance (Reisman, 2005). Ideally, technology transfer does not include expenses for the transferor and transferee (zero cost

[3] It stands for PeneLITian, PengemBANGan, PenkaJIan and peneRAPan.

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v13i3.846

transaction). However, with changes in the market environment, the technology provider can earn, in the form of a license, while the transferee will earn profit from selling the product in the market. Agents involved in technology transfer could be involved in either an external technology transfer and/or internal technology transfer. The modality characteristic determines the mode of transfer, effectiveness, expenses, price, and some agents.

In 2021, the NRIA was established as the only national scale think tank through Presidential regulation number 78 of 2021[4]. It was later updated to Presidential Regulation No 78 of 2021. The NRIA assists the President in carrying out research, development, assessment, and implementation, as well as nationally integrated inventions and innovations and monitoring, controlling, and evaluating the implementation of tasks. All government research and development institutions, including those under the technical ministry and local governments will be under the NRIA. The structure consists of 7 Deputies, each of which oversees several directorates, namely:

1. Deputy for Development Policy
2. Deputy for Research and Innovation Policy
3. Deputy for Human Resources in Science and Technology
4. Deputy for Research and Innovation Infrastructure
5. Deputy for Research and Innovation Facilitation
6. Deputy for Research and Innovation Utilization
7. Deputy for Regional Research and Innovation

Technical activities of research, development, assessment, application as well as inventions and innovations are carried out by non-structural organizations called Research Organizations consisting of the following areas:

1. Nuclear Power
2. Aviation & Space
3. Technology Assessment & Application
4. Life Sciences
5. Earth Science
6. Engineering Science
7. Social Sciences, Humanities
8. Marine & Fisheries
9. Archeology
10. Metrology
11. Religion & religion
12. Language & Literature
13. Environment & Forestry
14. Governance & Community Welfare

[4] The implementation of national research and innovation is regulated by Presidential Regulation No. 33 of 2021 which was issued on April 28, 2021, and revised by Presidential Regulation No. 78 of 2021 which was issued on August 24, 2021.

15. Agriculture and Livestock
16. Health

This research does not distinguish the structure and arrangement of research institutions in the two presidential regulations. In accordance with the limitations of the research, the technology transfer under study is the transfer of technology providers using government budgets.

4. Methods

This study employed an AHP approach. There were two phases of meetings for preparing questionnaires and interviews. The purpose of the first meeting was to determine the factors that should be included in the AHP. This was an important step to prevent the respondent from misinterpreting the questionnaire. The experts provided their advice in a weighted pair comparison between the factors of the AHP structure. This was followed by data confirmation and questionnaire validation. At our second meeting, we arrived with a questionnaire.

While there was deep discussion throughout the process of the AHP survey, most experts agreed that the core problem of technology transfer is the absence of a national research institute. Therefore, this was followed by establishing the National Research and Innovation Agency of the Republic of Indonesia. In this extensive research, the discussion before establishing the agency is provided as it is among the recommendations.

The variables presented in the questionnaire were made to facilitate understanding in the assessment of criteria so that the meaning of each of the variables in the questions were easy to understand. References related to variables are found in the research methodology section.

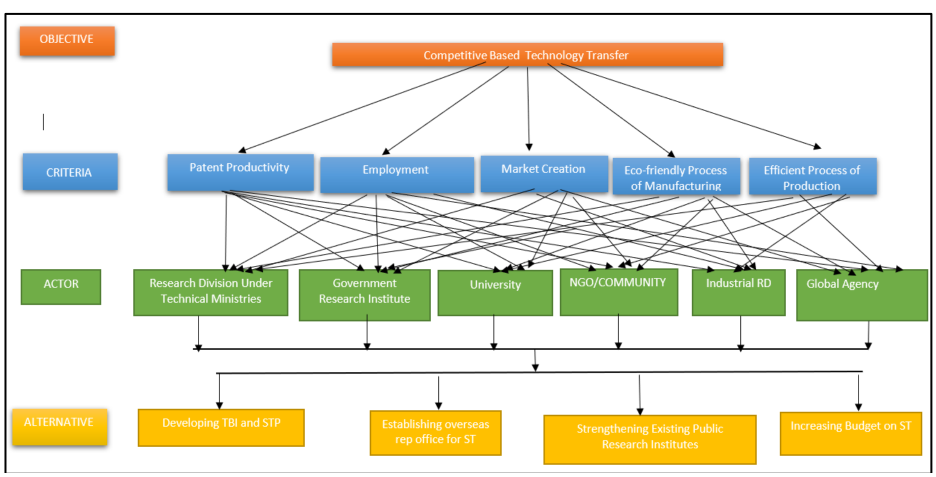

Figure 3 Pairwise structure for competitive-based technology transfer

Based on the first round of meetings with the experts, we developed a four-level hierarchy structure. The first layer of the structure is the objective of "achieving a competitive-based innovative technology." Strengthening the capacity of technology transfer is the objective of a technology transfer process according to the experts based on their experience and literature research. The experts concluded that the transfer of innovative and appropriate technology is essential. The second layer of the hierarchy structure contains the criteria. The experts agreed on five conditions for achieving the objective, including patent productivity, employment, market creation, the eco-friendly process of manufacturing, and the efficient process of production. In the first interview, the experts suggested that the patent should be viewed as the protection of intellectual production in the commercial field. In other words, the patent must be treated as a tool and not as an objective. Most public institutions put the number of patents achieved as their target which leads to high maintenance costs for IP. This has led to the business value of a patent being whether or not it is bankable[5]. However, new technology should also meet ecological safety standards. The third layer includes the agents or actors of technology transfer. The experts mostly agreed on six parties which include a research division under technical ministries, government research institutes, universities, non-government organizations, industrial R&D and global agencies. The fourth layer is the most important for the decision-maker and includes four alternative strategies which are building TBI and STP; establishing an overseas representative office for ST; strengthening existing public research institutes and increasing budgets for ST.

In the survey, each factor was compared and connected to the above factors. For example, at level 1, namely criteria, each factor was compared to support a goal. At level 2, the actor factors were compared to support each of the criteria listed at level 1. In discussions and surveys, it was necessary to adjust the description of the comparative factors because of the time pressure resulting from questions that seem to be repeated. Returning the focus of the discussion to each question was important in limiting the topic being discussed.

The ten AHP questionnaire files were entered into an AHP table created in Excel. The measurement of the consistency index of each respondent will help reconfirm the responses with a low level of consistency. This data was also used to combine the surveys from the ten experts using the geometric mean. Next, the combined ranking of the geometric mean was entered into the SuperDecisionss[6] software.

---

[5] The motivation for researchers to protect intellectual property is a measure of the achievements of universities and research organizations. This has led to an increase in the number of patents, which was not followed by an increase in the number of applications. The mistake was in considering the realization of the number of patents as an objective and not as a tool.

[6] SuperDecisions® is a decision support software that implements the AHP and ANP.

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v13i3.846

5. Results and discussion

The selected experts from the field of technology transfer were first contacted by the Academic Staff via letter followed by contacting either the key person or the secretary of the key person. Limited time in their schedules made it difficult to get an interview with the experts, which was a reason for not using a focus group. Based on the results of questionnaires that were appropriate in terms of consistency and sensitivity, the results are shown in Figure 4.

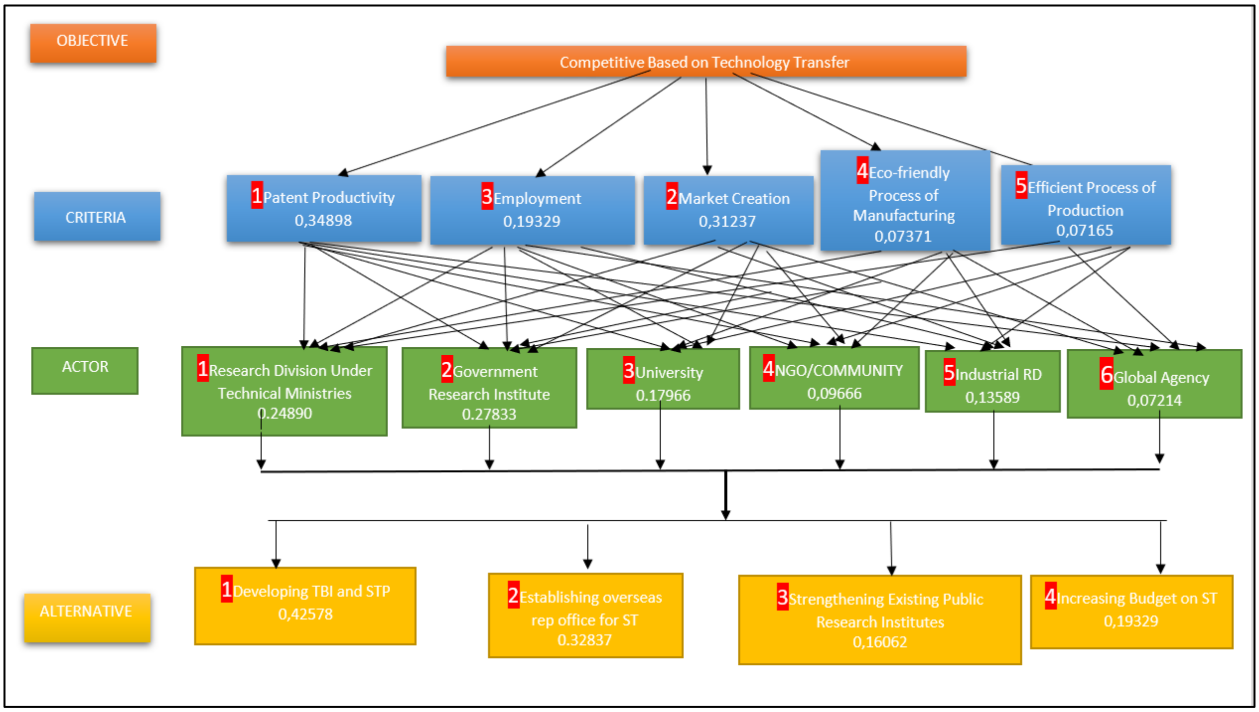

Figure 4 Weighted pairwise structure for competitive-based technology transfer

There were three modes of discussion in the first round of interviews. First, a combination of communication by email and telephone calls was used. During the first contact, we explained the objective of the research and the method of the interview. In this first round of interviews, experts were encouraged to ask, confirm or share their ideas and recommendations relating to the questionnaire. There were twelve government officials involved with technology transfer and innovation technology who agreed to participate in this project. However, two respondents preferred to respond to open-ended questions and via discussion, and another expert, due to very limited time, preferred to provide resources and share his experiences and ideas for technology development in Indonesia.

This structure was built based on recommendations from and discussion with an expert in the first meeting. The view of each element in the structure was strongly influenced by the background of their work. The experts suggested the key criterion of patent productivity in the success of the technology transfer process (weight=0.34898). When the protection of intellectual production does not lead to commercialization, it is recommended that another appropriability regime be used such as copyright in an academic publication. Patent registration with no exit strategy will result in expensive maintenance costs. This criterion was also chosen based on the different treatment of patents by public and private organizations. Some public research institutes treat IP as a target of IP management. In the firm, IP was treated as a tool for protecting operations based on new technology. When a patent is treated as a target of the innovation process, patent registration as well as the maintenance cost will increase. However, in this scenario, there will be no return for either the inventor or the office.

Employment (weight=0.19329) was another criterion that experts endorsed to consider the importance of government expenditure that should be returned to the taxpayer. The growing population of Indonesia has experienced increased unemployment. Development in science and technology is likely one alternative to absorb unemployment. It relates to establishing TBI and STP where new entrepreneurs are created. There were fourteen agreements[7] on utilizing technology between LIPI and businesses that called for job applications to work in the center.

Market creation was regarded as the second most important criterion (weight=0.31247). The application of new technology can create demand. Feasibility studies equip the producer to sell the product. The flow of technology in the market sometimes leads to a market-driven push for research. In this regard, the technology provider considers how their research could solve the problem; however, there is limited consideration of potential customers (Di Stefano et al., 2012; Herstatt & Lettl, 2004; Moerle & Specht, 2014). This is similar to the resource-based view (RBV) which believes that business development should begin with internal capacity. In this view, the researchers satisfy their curiosity and desire to participate in intellectual activities, but there is limited consideration of the potential customer.

Another concept of marketing innovation-based products is being market-driven and implies that product development should consider the preference of the market (Horbach et al., 2012). For example, if the market wants the product painted red, then it is better not to sell a product that is painted black. Experts found that the impact of technology transfer should be measured and justified by developing the right policy.

Eco-friendly innovative products are available in some research centers in Indonesia. Experts successfully showed the number of research proposals for advanced technology that were developed by local scientists. However, these products do not meet the demands in the market. One expert presented the case of anti-fouling paint that was developed in one research center in Indonesia. Under the International Standard of Maritime Industry, every vessel that sails over international borders should use special anti-fouling paint that does not destroy the environment. There are many other eco-friendly products developed in research centers that fail to go to market.

[7] English version of this information could be accessed in http://inovasi.lipi.go.id/en/profile/agreement

Learning from industrial countries that meet the efficient process of production by utilization of innovation, technology transfer should support the low-cost manufacturing process (weight=0.07165). However, it seems that when technology comes to an existing industrial cluster, it can lead to the bankruptcy of that industry. Experts shared the case of the apparel industry in West Java that closed when a technology program was introduced to the cluster. Another example was the Agri-industry in North Sumatra that closed as a collaborative program from Indonesia and an international body applied technology and a new business process. Therefore, this criterion was worth including.

Most experts agreed with the key actors capable of strengthening the technology transfer system in Indonesia. Actors play an important role in establishing key research that meets the demand as a bankable product or the research that assists small and medium entrepreneurs and farmers.

Four alternative schemes should be considered to establish a better outcome of technology transfer. Based on the different backgrounds of their work, several different nomenclatures with similar meanings were used to describe the expert's position. Some experts were called the manager of product development (McD), and others were called the Chief Innovation Officer (CIO). The research scheme was built to consider the differences of terminology.

5.1 Evaluation of criteria

The rank of the weight of the individual variables in the selected criteria is as follows, from highest to lowest: patent productivity (0.34898), market creation (0.31237), employment (0.19329), eco-product (0.07371) and better cost of product (0.07165). Patent productivity was ranked first along with market creation within the criteria cluster.

The success of the technology process on a macro scale is a measure of increasing awareness of intellectual property that could be valued by the number of patents created and utilized. The budget allocation for patent development in public research institutes should be treated as a long-term investment which is different from patent success in the private sector. It leads to the valuation of the technology when considering whether one particular outcome of the research has industrial application when the selected technology is submitted to the patent office to determine the novelty of the technology. Alternatively, the research and development division in the manufacturing industry gets the ideas through an internal process and external environment that can lead to intellectual protection. Therefore, most technologies have been operated internally before the protection process while new technology developed in a public research institute would enter the market trial and licensing procedure. The key criterion of successful technology transfer is patent productivity.

Market creation is the second most important variable to achieve a competitive-based innovation technology. Technological change plays a strategic role in strengthening national competitiveness and requires a migration path from idea creation to prototyping, and a minimum viable product to a commercial product. For example, the migration from a paging communicator to a cellular phone or smartphone required certain migration paths. Users do not instantly accept new technology while the product cycle for advanced technology may last for a shorter time. However, when the efficiency of production leads to a lower product price in the market and is supported with better promotion, the business can meet people's demands. Migration paths for individual technologies are created differently (innovation creates its artery). Also, targeted consumers are not always equipped with sufficient information to decide whether they need one particular kind of advanced technology or another. People often form their interests and demand based on the outcome of the product (outcome-driven innovation).

The group of experts aligned the variable of market creation (0.31237) with the efficiency of the manufacturing process (0.07165). In most cases, the initial phase of developing an applied technology has high risk and uncertainty. In the next stage, when the new technology has achieved its target, the old manufacturing process becomes expensive and unreliable. In informal discussions, experts highlighted the important role of standards as a criterion for competitiveness. Innovation-based products should meet product standardization and intellectual property.

5.2 Evaluation of actors

The actors are weighted from highest to the lowest as follows: Government Funded Research Institutes (GFRI), (0.27833), research division under Ministerial Office, (0.24890), universities, (0.17966), private R&D, (0.13589) and foreign agencies, (0.07214). The experts believe that Government Funded Research Institutes are the top actors that play a significant role in the technology transfer process. The core function of GFRI in the technology transfer system is to plan, conduct and develop technology, and they have contributed significantly to the policymaking process by providing information and policy recommendations. This recommendation was acted on by the government by establishing the NRIA. However, the transition has experienced delays due to procedural budgeting and human resources allocation. Also, the COVID-19 pandemic provided the researcher with unlimited working hours from home.

The research and development division in the Ministerial office provides solutions to technical problems identified by the Ministerial office. This division has a close relationship with the core function of the Ministerial office where most of the technology created by the researcher was developed and utilized.

Public-funded research institutes and technical divisions under the ministerial office would be the two groups of actors integrated into the NRIA. This is expected to open pathways between researchers and make the flow of basic research to application more controllable. However, there are two different opinions regarding the concept of technology transfer under the NRIA. First, a group of researchers and stakeholders have a pessimistic view that based on the background of transferring technology it is highly unlikely that it will go from basic to development and application at the end of the tunnel. Every actor has his own methods and potential users. The second group believes that the problem of technology transfer is not about institutional arrangement. They see the problem as the narrow view of the decision-maker and believe the solution should come

from a higher level. Parliament should also be a representative of experts at universities and research institutes. This would reduce the unbalanced view of developing science and technology capability and technology transfer.
Universities contribute significantly to the technology transfer system supported by both the quality and quantity of new students (worker bees). Research in the university begins in laboratories or classes with joint work between lecturers and students. Youth programs to create entrepreneurs are introduced to students, including financial incentives, business coaching, and the privilege to access research facilities on campus including an expert in a particular field. Local Area Network (LAN) and touchscreens are success stories of technologies developed by GFRI (Mazzucato, 2011).

Most non-government organizations (NGOs) work directly or indirectly in the technology transfer process and are related to eco-products, agribusiness for women, energy, and food processing. Funding comes from international actors that represent developed countries or international organizations. NGOs are more responsive than government bodies due to their tight connection with the user, especially in the fields of agribusiness and small business.

The role of private enterprises in the technology transfer process is still small. Most manufacturing sites are not equipped with an R&D division. The principal of a business provides equipment, supplies and production manuals for a manufacturing process that maintains the stability of the supply and standards of the product. However, in some cases, this closes the opportunity for collaboration with domestic research institutes. Indonesia is considered to have a growing market that follows the increasing number of middle-class. Technology-based-products such as automobiles and smartphones are in sufficient demand, but this demand has not been followed by the development of an internal research division.

Foreign agencies in this research are the domestic technology provider as representatives of foreign countries, universities, bodies, or research institutes. Most collaboration occurs for non-commercial research outcomes, such as joint research, joint publication, student exchange and scholarships.

5.3 Evaluation of policy recommendation

The important outcome of the AHP decision-making process is the ranking of alternatives for action (strategies) that can be translated into policy recommendations. The highest weight is establishing a technology and business incubator (TBI) and science and technology park (STP) (0.42578), followed by opening an overseas-science-representatives office (0.32837), strengthening existing public research institutes (0.16062) and increasing government expenditure on research and development (0.19329).

Experts ranked TBI and STP (0.42578) as the most significant for introducing new technology to the user as well as protection from risk and uncertainty for both researchers and entrepreneurs. New technology is achieved through market validation and appropriate trials for a reliable product. A TBI would be developed inside a university

ISSN 1936-6744
https://doi.org/10.13033/ijahp.v13i3.846

campus and be closely aligned with experts. A STP treats technology in the wider space which is supported by sufficient access to industry as the user of technology and the scientist as the technology provider.

The results indicate that policymakers in Indonesia should establish science and technology representatives. Experts were able to show that international research collaboration was attached to a particular individual scientist. This flagship was very flexible, easy to set up and easy to fail. Globalization required a wider and stronger engagement and communication in the field of science and technology. Experts also found a growing number of visits of foreign bodies to research installations in Indonesia, but these were generally not well represented. Indonesia has had Education Attachés that did not cover the subject of science and technology. Education Attachés are required to be a certified lecturer or teacher who emphasizes student and youth exchange programs.

Regulators found strengthening existing science and technology institutions to be more important than increasing GERD. Many parties had advised the government to increase the budget allocation for ST. However, the experts found that items of ST were extremely flexible and that fluctuations in the budget had influenced the results of research activities. One expert suggested that if the budget was not limited, then the results would still be the same, which was indicated by the same research proposal, the same outcome and the same researcher. Another view suggested that, a research organization with old equipment and an old building needed to be refurbished. Therefore, increasing GERD (0.19329) was more important than strengthening existing research institutes (0.16062).

6. Conclusion

The highest score in every layer was patent productivity (0.34898); followed by Government-Funded Research Institute (0.27833) and establishing the Technology Incubator and Science Technology Park (0.42578).

The number of patents generated by national research institutes is lower than a global player in Indonesia; hence, patent productivity has become the greatest target for the public research institute. However, patents should be treated as the pathway for bankable and commercial utilization because setting a patent as the target will create maintenance costs.

Government-funded research institutes are expected to play a significant role in the technology transfer system. Centralization of public research institutes with technical divisions under the ministerial office in the NRIA would be the right decision if and only if, it is equipped with a comprehensive arrangement that involves stakeholders.

While several developed countries have experienced successful TBI and STP, the experts found that it would also increase the technology utilization in Indonesia. The private sector should be involved in creating a productive STP and TBI. This research is relevant because of the establishment of the NRIA which is based on the inefficient government

R&D budget, which was the unpopular alternative on the AHP structure. There are three other important recommendations of this research for the NRIA.

7. Further research

During a discussion of the AHP questionnaire in December 2017, the need for reconsideration of bicameralism in Indonesia was raised. This is related to the status of a publicly funded research body and the indirect interference of a political party. It occurred when integration of the structure of the Ministry of Research and Technology with the Ministry of Education of the Republic of Indonesia as part of the formation of the NRIA was a risk of political compromise in the government's R&D development at that time.

REFERENCES

Bercovitz, J., & Feldmann, M. (2006). Entrepreneurial universities and technology transfer: A conceptual framework for understanding knowledge-based economic development. *Journal of Technology Transfer*, *31*(1), 175–188. https://doi.org/10.1007/s10961-005-5029-z

Blohmke, J. (2014). Technology complexity, technology transfer mechanisms and sustainable development. *Energy for Sustainable Development*, *23*, 237–246. Doi: https://doi.org/10.1016/j.esd.2014.09.003

Bozeman, B. (2000). Technology transfer and public policy: a review of research and theory. *Research Policy*, *29*(4–5), 627–655. Doi: https://doi.org/10.1016/S0048-7333(99)00093-1

Chehrehpak, M., Alirezaei, A., & Farmani, M. (2012). Selecting optimal methods for the technology transfer by using the analytic hierarchy process (AHP). *Indian Journal of Science and Technology*, *5*(4), 2540–2546.

Costantini, V., & Liberati, P. (2014). Technology transfer, institutions and development. *Technological Forecasting and Social Change*, *88*, 26–48. Doi: https://doi.org/10.1016/j.techfore.2014.06.014

Delgado, M., Ketels, C., Porter, M. E., & Stern, S. (2012). The determinants of national competitiveness. *Zhurnal Eksperimental'noi i Teoreticheskoi Fiziki*, 47. Doi: https://doi.org/10.3386/w18249

Di Stefano, G., Gambardella, A., & Verona, G. (2012). Technology push and demand-pull perspectives in innovation studies: Current findings and future research directions. *Research Policy*, *41*(8), 1283–1295. Doi: https://doi.org/10.1016/j.respol.2012.03.021

Direktorat Jenderal Hak Kekayaan Intelektual Republik Indonesia. (2017). *Pendaftaran Paten Lokal dan Internasional di Indonesia 2015 - 2017*. http://statistik.dgip.go.id/statistik/production/paten_negara.php

Erensal, Y. C., & Albayrak, Y. E. (2007). *Transferring appropriate manufacturing technologies for developing countries*. Doi: https://doi.org/10.1108/17410380810847891

Gerdsri, N., & Kocaoglu, D. F. (2007). Applying the Analytic Hierarchy Process (AHP) to build a strategic framework for technology roadmapping. *Mathematical and Computer Modelling*, *46*(7–8), 1071–1080. Doi: https://doi.org/10.1016/j.mcm.2007.03.015

Herstatt, C., & Lettl, C. (2004). Management of "technology push" development projects. *International Journal of Technology Management*, *27*(2/3), 155. Doi: https://doi.org/10.1504/IJTM.2004.003950

Horbach, J., Rammer, C., & Rennings, K. (2012). Determinants of eco-innovations by type of environmental impact - The role of regulatory push/pull, technology push and market pull. *Ecological Economics*, *78*, 112–122. Doi: https://doi.org/10.1016/j.ecolecon.2012.04.005

Horvath, B., & Kelsen, H. (1957). What Is justice? Justice, law, and politics in the mirror of science. Collected essays. *The American Journal of Comparative Law*. Doi: https://doi.org/10.2307/837546

Kumar, S., Luthra, S., & Haleem, A. (2015). Benchmarking supply chains by analyzing technology transfer critical barriers using AHP approach. *Benchmarking: An International Journal*, *22*(4), 538–558. Doi: https://doi.org/10.1108/BIJ-05-2014-0040

Kumar, S., Luthra, S., Haleem, A., Mangla, S. K., & Garg, D. (2015a). Identification and evaluation of critical factors to technology transfer using AHP approach. *International Strategic Management Review*, *3*(1–2), 24–42. Doi: https://doi.org/10.1016/j.ism.2015.09.001

Kumar, S., Luthra, S., Haleem, A., Mangla, S. K., & Garg, D. (2015b). Identification and evaluation of critical factors to technology transfer using AHP approach. In *International Strategic Management Review* (Vol. 3, Issue 1). Holy Spirit University of Kaslik. Doi: https://doi.org/10.1016/j.ism.2015.09.001

Lee, S., Kim, W., Kim, Y. M., Oh, K. J., Ahmadabadi, M. N., Najafi, M., Gholami, P. P., & Gholami, P. P. (2013). Using Analytic Hierarchy Process (AHP) to use intangible factors for technology transfer adoption. *Expert Systems with Applications*. *39*(7), 6388-6395. Doi: https://doi.org/10.1016/j.eswa.2011.12.030

Mazzucato, M. (2011). *The entrepreneurial state: Debunking private vs. public sctor myths*. PublicAffairs.

Miller, G. A. (1981). Trends and debates in cognitive psychology. *Cognition*, *10*(1–3), 215–225. Doi: https://doi.org/10.1016/0010-0277(81)90049-4

Moerle, M., & Specht, D. (2014). *Technology Push*. Gabler Wirtschaftslexikon.

Pusat Inovasi LIPI. (2017). *IP Port Pusat Inovasi*. http://inovasi.lipi.go.id/id/hki

Reisman, A. (2005). Transfer of technologies: A cross-disciplinary taxonomy. *Omega*, *33*(3), 189–202. Doi: https://doi.org/10.1016/j.omega.2004.04.004

Saaty, T. l. (2003). Saaty T.L. (2003), The Analytic Hierarchy Process (AHP) for decision making and the Analytic Network Process (ANP) for decision making with dependence and feedback. *Creative Decisions Foundation*, 114. http://www.rwspublications.com/books/

Sipahi, S., & Timor, M. (2010). The analytic hierarchy process and analytic network process: An overview of applications. *Management Decision*, *48*(5), 775–808. Doi: https://doi.org/10.1108/00251741011043920

Slaughter, S., & Rhoades, G. (1996). The emergence of a competitiveness research and development policy coalition and the commercialization of academic science and technology. *Science Technology and Human Values*, *21*(3), 303–339. Doi: https://doi.org/10.1177/016224399602100303

Wang, B., Shyu, J. Z., Cheng, C. C., & Hsieh, C. H. (2009). Changing technology transfer strategies in a non-profit organization - An examination of ITRI. *International Journal of Innovative Computing, Information and Control*, *5*(6), 1527–1538.

Yazdani, K., Rashvanlouei, K. Y., & Ismail, K. (2011). Ranking of technology transfer barriers in developing countries; a case study of Iran's biotechnology industry. *IEEE International Conference on Industrial Engineering and Engineering Management*, 1602–1606. Doi: https://doi.org/10.1109/IEEM.2011.6118187