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Measuring Technological Innovativeness of Indonesia's Manufacturing Companies: A Pilot Testing

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Abstract: Indonesian manufacturing companies recognize the importance of technological innovation to improve their competitiveness in the global competition. They need a measurement tool to assess and improve their innovativeness which is suitable for Indonesian context. The study focuses on manufacturing sector due to its substantial contribution of Indonesian economy and its big challenges. A measurement model, as a function of the activities in the technological innovation process and the management of the innovation and its measurement tool to assess the innovativeness of a company have been developed using cases in 4 companies in pharmaceutical and Information and Communications Technology (ICT) industry. Consequently, the measurement tool is expected to help Indonesia's manufacturing companies to recognize their state of innovativeness and eventually improve it. This study describes the pilot testing of the measurement tool, using questionnaires sent to manufacturing companies in Indonesia which classifies company's innovativeness into CLAS-category (creative, lucky, automatic and superb). The measurement tool has predicted that most of companies in pharmaceutical and ICT industry are classified in superb-category. It has also predicted the innovativeness categories of other companies reasonably well.

Key words: Innovation activities, innovativeness category, management of innovation, manufacturing sector, measuring innovativeness

INTRODUCTION

Indonesia recognizes the important of innovation to compete globally. The recent government master plan for the acceleration and expansion of Indonesia's economic development (MP3EI) outlines several action to make the shift toward better productivity, innovation and creativity, driven by science and technology. In the manufacturing sector, Indonesian companies have to improve their products quality, come with innovation to offer higher added value, so that they do not have to compete on cost only and move upward in the value chain rather than doing basic processing activities (World Bank, 2012a).

The manufacturing sector contributes a substantial 20.8% to Indonesian GDP in 2012 which decline declines slightly from 20.92% in 2011 (MoI, 2013). Though still growing, the growth of Indonesia's manufacturing in 2000's (±5%) is much lower than before the crisis in 1998 (±12%) (World Bank, 2012b). The crisis has also resulted in much less integration of Indonesia's manufacturing to global production networks compared to other countries in South East Asia, such as Malaysia, Thailand and Philippines. The sector is facing the well acknowledged problems, such as infrastructure and logistic cost, as well as more critical problems, such as the high dependency on natural resources, cheap labor and huge domestic demand (MoI, 2013).

Within the manufacturing sector, this study selects the pharmaceutical industry and Information and Communications Technology (ICT) industry because these industries are key contributors in the manufacturing sector and both are highly needed in Indonesia. The selection is supported further by the fact that most of machineries, electronics and chemical products are imported (MoI, 2013) while those products are highly needed in Indonesia. For example, Indonesian pharmaceutical companies currently only focus on finding off-patents generic medicines, licensing medicines from foreign companies and produce medicines with raw materials supplied from foreign companies (Sampurno, 2007). With the threat of increasing global, as well as regional competition, such as a single ASEAN market, Indonesian pharmaceutical companies need to consider knowledge-based development and increased R&D activities to find new medicines.

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The ICT industry has also contributed significantly to Indonesian economic growth which can be seen in US$32.8 billion ICT expenditures in 2013. However, most of the products are still imported.

At the moment, there is no available approach to be found that can be easily used by Indonesian companies to assess their innovativeness. Research on innovation measurement has focused primarily on input and output factors of innovation but increasingly on the activities during the innovation process (Harper and Becker, 2004; Dodgson *et al.*, 2005; Cooper and Edgett, 2012). The alternative measurement frameworks proposed in the prior literature are introduced and discussed.

Literature review: There are various definitions of innovation where Read (2000) observed that even though, no single generally accepted definition of innovation exists, key characteristics of an innovation include newness, usefulness and involves both processes and outcomes perspectives. So, it is necessary that innovation is recognized by people who have benefits from it and perceived to include new ideas which cover technological innovation (products or services) and managerial innovations (Van de Ven, 1986). Specifically, this study uses the definition that innovation has to offer economic value by providing new solutions (Zawislak *et al.*, 2009).

The definitions of innovativeness are also varied between organizational capabilities (Ettlie *et al.*, 1984; Lumpkin and Dess, 1996; Mairesse and Mohnen, 2002; Cho and Pucik, 2005) and product qualities, as results of innovation (Garcia and Calantone, 2002; Oke, 2007). This study adopts the definition of innovativeness, as an organizational capability: Company innovativeness is the tendency of a company to innovate or develop new products (Ettlie *et al.*, 1984).

There are also various research on measuring innovativeness in a company (Adams *et al.*, 2006; Phan, 2013). Some researchers focus on measuring the driving (input) factors that lead to innovation results (Damanpour, 1991; Capaldo *et al.*, 2003; Martensen *et al.*, 2007). Some other researchers focus on output factors, as measurement items for innovativeness in a company (Chuang, 2005; Alegre *et al.*, 2006; Phan, 2013).

Next group of researchers consider the whole innovation process and try to make measurement framework that assess it accordingly. Chiesa *et al.* (1996) developed a framework for auditing technological innovation management. They argue that innovation needs good practices in relevant management processes and organizational mechanisms. They defined 4 core processes: Concept generation, product development, process innovation, technology acquisition and 3 enabling processes that support the core processes: Resources, systems and tools, leadership. However, they did not specifically consider the actual activities during innovation.

Adams *et al.* (2006) have synthesized an integrated framework that described the management of innovation construct which are represented by 7 major processes which includes: Inputs, knowledge management, strategy, organization and culture, portfolio management, project management and commercialization. They focus on the way to effectively manage innovation but they do not discuss the specific activities in the technological innovation process. They admit that their framework has to be used in specific context for a company, however there are no detail suggestions about the context.

Brophey and Brown (2009) proposed a measurement framework based on empirically identified innovation processes in mechanically-based small and medium manufacturers. They identified the activities in five main innovation processes (idea generation, idea screening, idea implementation, enabling forces and barrier to innovation). However, they have limited their results only for the considered industry.

Research purpose and question: This research aims to build a new framework to measure innovativeness in a company by identifying the actual technological innovation process, in Indonesian pharmaceutical and ICT companies and their related management of innovation. Hence, this study tries to answer the following question:

> How to measure the technological innovativeness of a company, so that a classification scheme can be formulated for assessing the capability status of a company, as a function of 2 constructs: The activities during the technological innovation process and the management of innovation?

The variables in the 2 constructs are collected empirically using case study research while the derived measurement items will be tested in quantitative approach using a questionnaire. This study reports the results of the pilot testing.

MATERIALS AND METHODS

The first part of the research is a qualitative study in which an interpretive approach is used for building the knowledge of innovation activities in a company by observing and interpreting human interaction in real activities. This approach attempts to obtain rich pictures and deep understanding of innovation processes in a company and therefore, a case study research is selected wherein the data is collected from in-depth interviews and other multiple sources of data (De Weerd-Nederhof, 2001; Yin, 2003; Gibbert *et al*., 2008). The case study research is carried out according to the wide accepted approach from Eisenhardt (1989) and Yin (2003) and divided in 2 phases: Building conceptual model using literature review and emerging model using case study research and confirming the measurement model and defining the measurement items and their contribution using an expert panel. All interviews are recorded with a digital voice recorder, transcribed and put into NVivo10 software for analysis.

The 2 pairs of cases are selected from pharmaceutical and ICT industry wherein each pair represents 2 types of product innovation: Incremental innovation and radical innovation. In pharmaceutical industry, the first type of innovation will be represented by the development of a supplement for prevention and treatment of osteoporosis in pre and postmenopausal women, called Hi-Bone, at PT. Otto pharmaceutical industries (Otto from here on). The second type of innovation will be a case at PT. Kalbe Farma (Kalbe) where a spin-off company, called Kalbe Genomics (KalGen) commercializes results from its Stem Cell and Cancer Institute (SCI).

In ICT industry, the development of a critical and highly priced part of GPS system, called GPS Time Sync, at PT. Hariff Daya Tunggal Engineering (Hariff) represents an incremental innovation and radical innovation is examined by a case at PT. LEN (LEN) during the development of an interlocking system as main part of a signaling system.

Members of the expert panel are researchers from reputable university and government research institution in Indonesia, 5 professionals from Indonesian pharmaceutical and ICT companies and 2 entrepreneurs, each from pharmaceutical and ICT industry. The experts on this panel discussed the activities during innovation process and management of innovation which were initially identified from the cases and determine the variables and their contribution.

Next a pilot testing is done in which questionnaires are sent to manufacturing companies in Bandung, Jakarta and Bekasi, 3 cities where many manufacturing companies are located. The respondents are selected using purposive sampling where most companies are pulled from the database of the university, either alumni or partners and from researcher's network. The researcher has received 104 filled questionnaires from 250 questionnaires sent. The 3 questionnaires have been discarded because they contain too many missing items, so only 101 questionnaires are processed further.

In the 1st phase of case study, data are analyzed using the sequence of open coding, axial coding and selective coding (Neuman, 2006). This sequence leads to grouping (finding themes) and finally extracting the concepts and proposing the variables.

In the 2nd phase, the expert panel discussed the measurement factors defined from the case in phase 1 and determined the relative importance of the measurement items by assigning their weighing factors. The panel uses the Analytic Hierarchy Process (AHP) to determine the factors (Saaty, 2001) which is done using a Delphi Method. The Delphi Method is a structured group communication method for soliciting expert opinion about complex problems or novel ideas, through the use of a series of questionnaires and controlled feedback (Rowe and Wright, 1999; Day and Bobeva, 2005). Using Delphi Method avoids the problem of dominance from one or more experts during discussions. Researchers have various opinion of the number of participants in the Delphi Method: As few as three to hundreds or thousands participants (Rowe and Wright, 1999; Thangaratinam and Redman, 2005), 10-15 participants (Day and Bobeva, 2005; Phan, 2013) or minimum of seven participants (Inaki *et al*., 2006). All ten members of the expert panel have participated in the discussion on the measurement factors but only seven completed all steps of the Delphi Method.

In the pilot testing, data from questionnaires are analyzed using the multivariate data analysis, such as reliability and factor analysis.

RESULTS AND DISCUSSION

This research contributes by creating a measurement framework that assess 6 main activities during technological innovation process and evaluates the related management of technological innovation.

Conceiving ideas: This group of activities represents the idea generation and characterized by good communication with all stakeholders and effort to look for new trends.

Acquiring information and transforming it into knowledge: This group of activities starts to work out ideas to become more an opportunity by doing cooperation and building competences.

Implementing and validating knowledge: Here, companies have to proof that they can make something from their knowledge. They participate in a production network.

Checking the appropriateness of the selected product regarding several aspects in marketing, operation and finance: Here, companies perform several activities to confirm that the selected innovation is appropriate in various aspects: Market, technology, manufacturing and operations and financial.

Commercializing phase 1: Getting customers or users and acquiring their feedback: The activities in this group represent a company's efforts to bring the product to market and get customers feedback, so they can improve the product.

Commercializing phase 2: Go and scaling up the project: In this phase, companies are confident to fully commercialize the product: Creating a spin-off company, building better supply and distribution channel and increasing marketing.

Supporting the above activities companies have to perform several management practices in three related areas, described in the following paragraph.

Strategy related: Strategy related management practices cover issues, such as giving direction of innovation having cooperation strategy, building competences, having R&D policy and knowledge sharing practices.

Resources related: Resources related management practices cover issues, such as leaders' commitment to allocate budget and resources, designing proper reward scheme, providing facilities and tools and providing the necessary trainings.

Operation related: Operation related management practices cover issues on a company organize its innovation such as doing job rotation for the employees, forming dedicated teams for product development, designing and implementing innovation system with its guidelines and clear decision criteria that is supported with data.

The expert panel has determined the contribution of each construct and its variables to the innovativeness of a company. The relative importance of the constructs and the variables in the construct are collected in Table 1.

Table 1: The weight factors as AHP results

Criteria	Weight factor	Sub-criteria	Weight factor
Activities	0.333	Conceiving ideas	0.225
		Acquiring information	0.098
		Implementing and validating	0.098
		Checking the appropriateness	0.177
		Commercializing phase I	0.225
		Commercializing phase II	0.177
Management of innovation	0.667	Strategy	0.500
		Resources	0.250
		Operation	0.250

This study identified that companies performed the above activities during innovation process with different sophistication of their knowledge, human capabilities and tools and facilities. This is in line with Sharif's argument that companies have to consider technology, as a system that helps them to make products or offer services. Therefore, companies have to build all technological system components which cover human, tools, informations and procedures (Sharif, 2012). Continuing Sharif's argument to indicate the innovativeness of a company, as a function of the level of sophistication of the technological system components, the following levelling is introduced: Basic level where the components such as facility and tools and human knowledge and skills fulfill the minimum requirement, intermediate level where the mentioned components are categorized as average in the industry and advanced level where the components belong to the best practices in the industry.

So, the measurement model is proposed to have the levelling as illustrated in Fig. 1. The different levels of sophistication of the technological system components between companies in the cases are recognized. In pharmaceutical industry both Otto and Kalbe have industry-standard production facilities, knowledgeable and skilled human resources and implement standard operating procedures.

However, Kalbe has taken another step upward by upgrading their laboratory which became the first ISO certificated genomic laboratory in the South East Asia. For the development of the Stem Cell and Cancer Institute (SCI) Kalbe has also hired some experienced PhDs in cancer and stem cell area. Therefore, as Otto may have an intermediate level of technological system components sophistication, Kalbe already has an advanced level.

Using available data from the cases, on the other hand both companies in ICT industry, Hariff and Len are considered having the Intermediate level of technological system components sophistication.

The finding, earliar shows that innovativeness measurement in a company has to be done by first examining the existence of 2 constructs: The activities and the management practices during innovation process and second, evaluating the state of their technological system components.

Though assured that no single company identity will be revealed, some companies decline to disclose their identity and their line of business (industry type). In those cases, the respondents are denoted as others (Fig. 2).

There are 17 respondents (16.8%) from pharmaceutical industry and 9 respondents (8.9%) from the electronics/ICT industry. Substantial amount

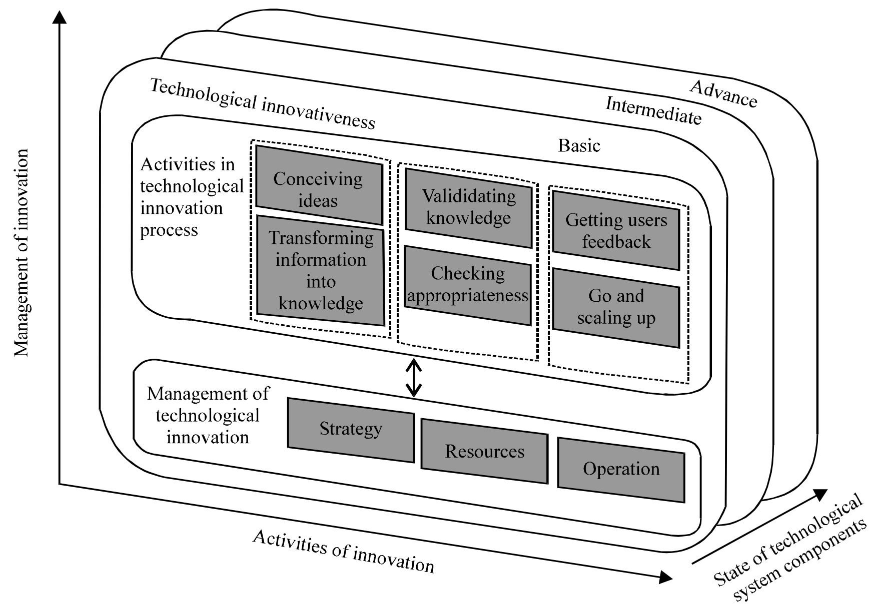

Fig. 1: Levels of technological system components sophistication

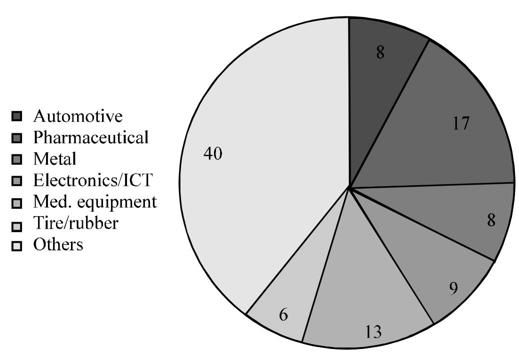

Fig. 2: The respondent distribution (type of industry)

of respondents comes from medical equipment (13 respondents), automotive (8 respondents) and metal industry (8 respondents).

This pilot testing calculates Cronbach's Alpha values (Table 2) as indicators of the reliability of the measurement items, i.e., the extent to which an item or a set of items is consistent in what it is intended to measure. Table 2 shows the initial Cronbach's alpha values and the values after some items are omitted to increase the contribution of the rest of the items in measuring the variable.

Next, it is checked whether the data support the use two constructs in the measurement model: The activities of innovation and the management of innovation. The data are utilized to do factor analysis for checking the structure of the variables by defining sets of variables that are highly interrelated.

Results of the factor analysis with a factor rotation which simplifies the factor structure and leads to better factor solutions are included in Table 3. All variables have high values of communality which mean that there is no variable stands out with low interrelation with other variables. So, all variables can be included in the measurement. The 2 factors extraction has a 69.4% of variance explained which is >60% and therefore is acceptable. Results in Table 3 suggest an indication of grouping such as:

- Group 1; variables 3-5 load high on factor 2
- Group 2; variables 1, 2, 6-9 load high on factor 1

The analysis shows that the variables can be put into 2 groups of variables. However, this grouping is some what different with the initial grouping which put variables 1-6, as the variables under the activities construct and variables 7-9 under the management of innovation construct.

It needs more data to arrive at final conclusion about the grouping. The researchers have also to examine the statements (items) in variable 1, 2 and 6 to ensure that they reflect the activities and not the related management of those activities. For this study, variables 1, 2 and 6 are kept in the group of the activity together with variables 3-5.

CLAS-category: In this pilot testing a score for a particular variable is determined by averaging the score, given by the respondent using a Likert scale from 1-4

Table 2: The Cronbach's alpha: Initially and after items deletion

Variables	Cronbach's alpha	No. of items	Cronbach's alpha	No. of items
Conceiving ideas	0.799	8	0.799	8
Transforming information into knowledge	0.755	11	0.776	8
Validating knowledge	0.652	8	0.675	6
Checking appropriateness	0.758	6	0.758	6
Getting users feedback	0.761	5	0.761	5
Scaling up	0.721	8	0.721	8
Strategy related management aspects	0.770	11	0.805	9
Resources related management aspects	0.906	13	0.915	10
Operations related management aspects	0.853	10	0.853	10

Table 3: Rotated factor loadings and communalities, varimax rotation

Variables	Factor 1	Factor 2	Communality
Conceiving ideas	0.7080	0.4130	0.6720
Transforming information into knowledge	0.6050	0.4620	0.5800
Validating knowledge	0.3950	0.7260	0.6840
Checking appropriateness	0.3730	0.8040	0.7860
Getting users feedback	0.1300	0.7880	0.6380
Scaling up	0.6510	0.3550	0.5500
Strategy related management aspects	0.8080	0.3820	0.7990
Resources related management aspects	0.8690	0.2010	0.7960
Operations related management aspects	0.8440	0.1630	0.7390
Variance	3.7241	41.4000	2.5184
Var. (%)	28.0000	6.2425	69.4000

of all measurement items in that variable. Then, the relative contribution of the 2 constructs with their variables is calculated using the weight factors in Table 1. The weighted score shows the location of the company innovativeness in a classification that contains 4 categories as illustrated in Fig. 3.

Total 5 imaginary companies are shown in the chart to indicate the extreme points that form a 4-box classification of company innovativeness, named CLAS-category which is described.

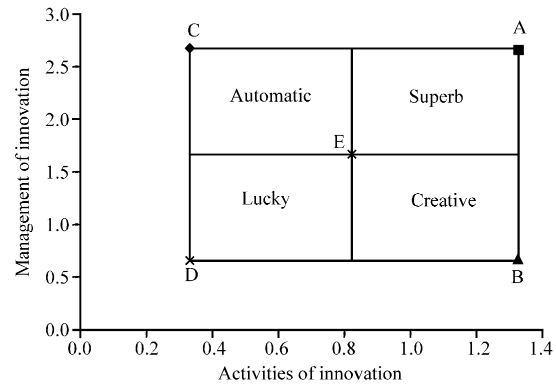

Fig. 3: CLAS-category of innovativeness

Creative-category; companies making creative innovation: In this category, innovation is determined mostly by the creativity of the employees in performing the necessary activities during innovation process (i.e., conceiving ideas, acquiring information and transforming it into knowledge, implementing and validating knowledge, checking the appropriateness of the selected product, getting customers or users and acquiring their feedback and scaling up). However, companies' supports in terms of the management practices in areas of strategy, resources and operation are not essential.

Innovations in these companies are driven by capabilities, competences and creativities of employees. They create innovation, even with little support from the management.

Lucky-category; companies making accidental innovation: Employees in companies in this category rarely perform the required activities during innovation process and the necessary management practices in areas of strategy, resources and operation are few either.

If any, companies in this category accidentally make innovations by luck or they make trivial innovations.

Automatic-category; companies making rational innovation: Companies in this category prepare the environment for innovation well by doing the necessary management practices in areas of strategy, resources and operation. So the companies provide good environment, facilities and tools for innovation. However, the employees do not often perform the required activities during the innovation process.

It is rationally expected that the employees automatically make innovations in these well-managed companies when the management add new tools, acquire new procedures or hire new experts. Innovations in these companies are limited in the area that does not demand much of employees' capabilities, competences and creativities to perform the required activities.

Superb-category; companies making comprehensive innovation: Companies in this category enjoy and benefit from the ability of employees to perform well the required activities during innovation process and the existence of good environment for innovation, as a result of supporting management practices in areas of strategy, resources and operation.

It is expected that companies in this category able to make comprehensive technological innovation that requires both employees' competences and support from management.

Results of this pilot testing indicate the innovativeness of the 4 companies in the case study research (Otto, Kalbe, Hariff and Len), as shown in Fig. 4.

They are all classified in the superb-category which is understandable, since they are selected for case study research as innovative companies in sector of high-technology industries. It is confirmed that technological innovations for these companies require the implementation of the activities during those innovations and supported by the necessary management practices. They have excellent employees to do the innovation activities and the management provides the necessary environment, facilities and tools. The measurement result also reflects the reality where it shows that in the pharmaceutical industry Kalbe is more innovative than Otto in terms of Kalbe performs the activities during technological innovation more often and the management practices of Kalbe are done more frequent and Kalbe also has higher technological system components sophistication (Fig. 5).

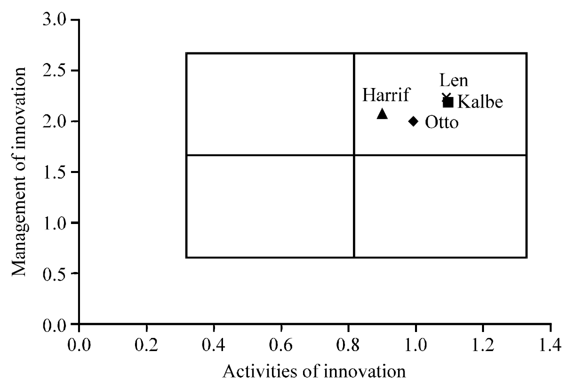

Fig. 4: The innovations of 4 companiesin case study research

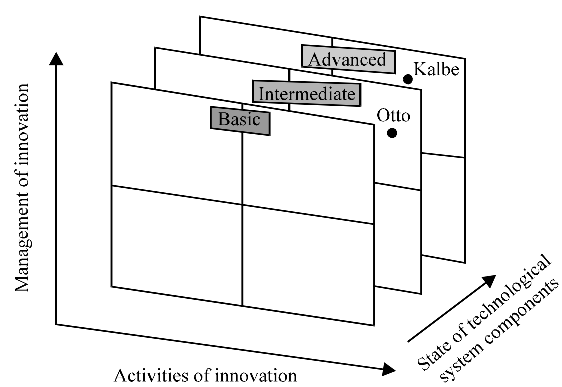

Fig. 5: Different levels of technological system components sophistication

In the ICT industry Len is more innovative than Hariff in the context that Len performs the activities during technological innovation more often and the management practices of Len are done more frequent to support innovation while they have the same level of the technological system components sophistication (Fig. 6).

The innovativeness positions of some other companies, in pharmaceutical and ICT industry that have participated in the pilot study are calculated for comparison. However, names of these companies are not disclosed to maintain the confidentiality agreement. A comparison between the innovativeness of pharmaceutical companies is shown in Fig. 7.

Kalbe and Otto are more innovative compared to the other companies, except for 1 renowned company (P3) which score better in the management of innovation practices. The 1 company is classified as a Creative-category company (P1) and another one, as an

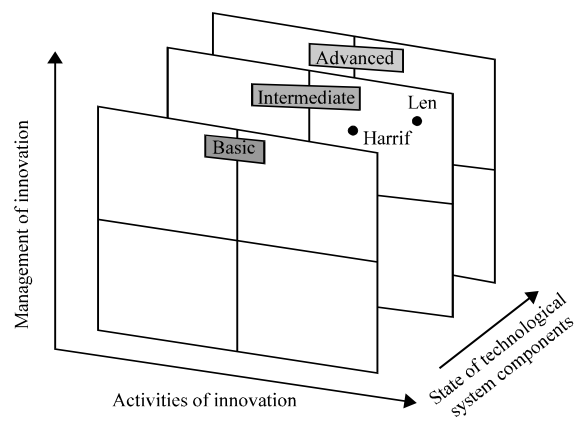

Fig. 6: Same level of technological system components sophistication

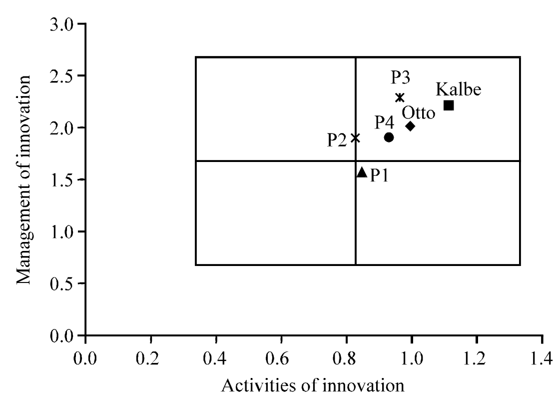

Fig. 7: Comparison of the innovativeness of companies in pharmaceutical industry

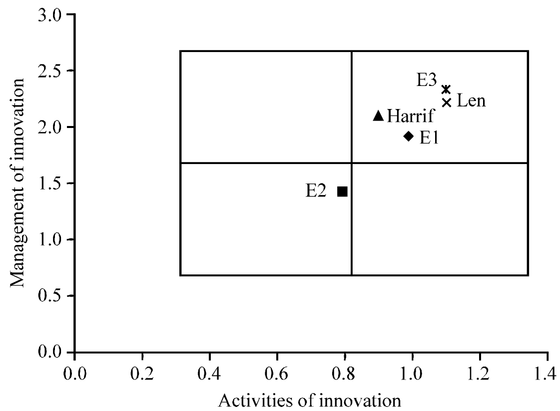

Fig. 8: Comparison of the innovativeness of companies in ICT industry

automatic-category (P2), though both are close to reach the superb-category. There is no sufficient data to assess the condition of other companies participated in the pilot testing, so no information can be given about the level of the technological system components sophistication. However, a general observation has confirmed that this measurement result reflects the reality. A comparison between the innovativeness of ICT is shown in Fig. 8.

Len and Hariff are more innovative compared to the other companies, except for 1 company (E3) which score better in the activity and management of innovation practices. The 1 company is classified, as a lucky-category (E2). Same as earliar, only a general observation can be done and it has confirmed that this measurement result reflects the reality.

This pilot testing indicates further that most the other participating companies are classified in superb-category, 6 companies are in creative-category, 12 companies are in lucky-category and 8 companies are in the automatic-category. Companies in creative-category are characterized either by small companies that make many low-risk and low-cost innovations, so the management does not have to intervene or very large state owned companies that seem to expect employees to do the activities during innovation without adjusting the management practices accordingly.

Companies in lucky-category are varied by size and industry. A first guess is that the companies in this category only focus on marketing the products while the product development is done elsewhere. Another, one is that the industry is so mature that not much innovation happens here.

Companies in automatic-category are also varied in size and industry. They have a common characteristic in the fact that they need advanced production facilities and tools. So, once the management provides those the companies are able to make some innovations.

CONCLUSION

This study has determined the activities and aspects of the management of innovation that are important to indicate the innovativeness of a company from which a measurement instrument is built in the form of a questionnaire that contains 70 measurement items for the 9 variables (6 activities during the technological innovation process and three aspects of the management of the technological innovation).

This research has computed the relative contribution of the 9 variables and the 2 constructs that group the variables to the innovativeness of a company. So, the state of the innovativeness of a company can be located in one of the 4-box categories, called CLAS-category which is a function of the 2 constructs: The activities during the technological innovation process and the management practices of the technological innovation.

All the 4 selected companies in the case study research are classified companies with innovativeness in the superb-category. This is consistent with the fact that innovation in these industries (pharmaceutical and ICT) required employees knowledge, skills and creativity, as well as supporting management practices. However, the four companies have different levels of the technology system components sophistication.

The measurement model and its measurement instrument can predict correctly the category of innovativeness of the manufacturing companies from various industries. Most of companies in this pilot testing are classified in the superb-category because they from industries with medium or high-technology intensity, so they need to perform the activities and support them with good management practices to make innovations. The measurement predicts reasonably well the innovativeness of companies in other categories as well.

However, the measurement model and its measurement instrument to assess the innovativeness of Indonesia's manufacturing companies should be considered preliminary and more research need to be done. More testing in pharmaceutical and ICT industry is needed to improve the measurement instrument.

The measurements are focused on activities during innovation and the related management practices. Level of technological system components sophistications is identified in the cases and discussed to some extent, however further study is recommended to analyze the relationship between that level and the innovativeness of a company.

More research in other industries in the manufacturing sector need, also to be done in order to check the applicability of the model to those industries to check the specific activities during innovation in those industries to build the specific measurement items for those industries and to study how to determine the level of the technological system component sophistication in those industries.

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