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Technology Capability and Technology Level Analysis

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ABSTRACT

This study is to explore technology capability and technology level analysis. This study focus on the function of technology capability that are proxy to technology leadership during the process of strategic flexibility at all levels of the corporation. This study integrates related theories and several previous studies. A macro and micro-view of technology capability and technology level evaluation is developed as a crosscurrent. This study provides decision-makers and policy makers with a managerial insight and strategic idea to present a roadmap for further research in this area.

Keywords: *Technology Capability, Technology Level , Technology Analysis*

INTRODUCTION

Today's business environment is changing rapidly. The thing that doesn't change can be realized by saying, "Everything changes except the words that everything changes." The pace of change in yesterday's business environment, today's business environment, and tomorrow's business environment reminds us of the speed war (Ong & Chen, 2013; Prajogo & Olhager, 2012). Until the mid-20th century, the external environment was compared to a mountain, but today's business environment can be compared to a desert.

In order for a country or a company to survive and grow in an infinite competition system, it needs an evaluation system that has core competencies and can accurately evaluate those core competencies (Lu & Ramamurthy, 2011). Although the core competencies can be expressed in many forms, they can be regarded as the technology of the state or its enterprises (Liu et al., 2016; Venkatesh, Thong & Xu, 2012). In the end, if we have superior technology compared to other countries and compared with other companies, we will be able to survive and grow in an infinite competition system and develop with permanence (Bongers, Geurts & Smits, 2000; Mikalef & Pateli, 2017). In addition, the ability to accurately determine the level of technology a country or a business has compared to its counterpart would allow it to develop a strategy to find the direction it or the entity should pursue (Tallon & Pinsonneault, 2011)

The methods of evaluation can be largely divided into quantitative (measuring) methods and qualitative methods, and in order to ensure objectivity, it is more reasonable to conduct quantitative (measuring) evaluations than qualitative ones (Adler, Friedman & Sinuany-Stern, 2002). Of course, it may be too much to quantify all assessments, and it would be necessary to establish and evaluation system to ensure consistent and directional results for anyone to evaluate.

In this study, we will focus on analyzing the characteristics of the technology level evaluation, studying the existing methods of the technology

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level evaluation system and analysis methods, analyzing domestic and international cases of technology level evaluation, and developing the technology level evaluation model so that the organization can reasonably derive the assessment of the technology level.

The purpose of this study is to explore strategic decision-making that the State or businesses can actually link to technology development strategies and R&D investment priorities by establishing a basic direction for technology level assessment through various methodologies and analysis of characteristics of technology level assessment and establishing a system for implementation.

TECHNOLOGY LEVEL EVALUATION

Schmookler (1966) defines technology as the social retention of knowledge related to industrial production, and defines it as a national technical capability or level of technology when the degree of utilization of existing technology is presented by summing up the distribution of that technology to a country's working population. Conceptually, the technical capacity similar to the capacity of a production plant is one of the most important economic resources of a country Thus, the growth rate of technological capabilities is the most important factor determining the limits of long-term economic growth rates. Gordon (1981) cited a mechanical device as an example of a technology level (State of Art: SOA), which targets the most advanced technology in the field and means that the use of the term "level" can give some degree of precision, but is an exogeneous measure of the type of technology measurement and of the effects of the technology.

After reviewing the results of pasts studies related to technology levels, Gordon presented the following five criteria for meeting technology level measurements of technology levels: First, when multiple analysts estimate technology levels for the same technology, they should be able to reach the same value. Second, the level of technology is ideally preferable in form of index, and the index should be based on reference values (concepts equal to the base year of index creation). This would indicate the proximity of the current technology level to the reference value, and would also provide a useful figure for the analyst. Third, this approach can be applied at any level of technical aggregation. Fourth, because technology is developed to achieve a particular single purpose or multiple objectives, the various parameters of the technology and the technology level index based on it must reflect the excellence of the technology in achieving its objectives. Fifth, the technology level should be in a dimensionless form to facilitate comparison between technologies. Martio (1993) said that a measure of the technology level quantitatively indicates how well the required function is performed. Level measurements of individual skills are also called measure of effect, and measure the ability of the technology to perform its intended function and its ability to solve problems.

After verifying the characteristics of these individual technologies, a single or multiple measurement representing the level of technology is selected and measured. In technology measurement, it is necessary to distinguish between technical parameters and functional parameters. It is desirable to use the technology parameter in establishing the R&D plan as a variable controlled by the designer to obtain the desired utility, and the functional parameter is a variable that measures the extent to which the technology satisfies the user's needs and is used in planning the marketing.

TECHNICAL LEVEL ASSESSMENT SYSTEM AND ANALYSIS METHOD

Methods for classifying methods of assessment of technology levels can be divided into classification by aggregation level of assessment targets and classification by approach. Classification technology level analysis according to the aggregation level of the assessment target can be classified into macro and micro approaches according to the aggregation level and utilization purpose of the analysis target, as shown in Table 1. Macroscopic approaches (structure and efficiency of inputs and outputs) are divided into the national technical level, the industrial level, and the enterprise's technology level, and the micro-access (performance and quality) are divided into the technical level of the technology field and the product technology level and are different for the purpose of utilization.

The Corporate Innovation System (CIS) approach attempts to objectively and systematically provide the information necessary to establish a technology strategy to achieve corporate goals and make decisions on technology management by analyzing the process of input, transformation and output of innovation, and illustrates the flow and measurability of information generated by the innovation system (Datta, 2011).

Table 1. Technical Capability and Level Assessment Methods

Qualitative method	Quantitative method
- Brainstorming - Delphi method - Interview method - Survey method - Face-to-face survey of experts	- Methods for analyzing paper, patent information - Score model - Principal Components Analysis - Analytic Hierarchy Process (AHP) - Technology readiness level (TRL) - Technical level evaluation using patent index - Evaluation of technology level using technology growth model

In order to systematically understand the organization’s technology development activities, it is desirable to prepare direct performance indicators such as investment and manpower input indicators and patents, and further to indicate the wide social and economic ripple effects of science and technology (Chen & Cates, 2018; Ringim, Razalli & Hasnan, 2015). The CIS approach has great significance in tracking the association and change between indicator components, and individual indicators are divided into R&D activity indicators that indicate the level of R&D activities, such as input and output of R&D, and industrial production activities and product technology levels, depending on the nature of the indicators (Kim & Fred, 2013).

The technology level evaluation system has a flow of conceptual establishment, purpose and necessity, classification of analysis targets, discovery of target technologies, evaluation of technology levels, analysis of factors of technological gap, establishment and activation of policy tasks. There are qualitative and quantitative methods for evaluating technology levels, and if you look at them, there are brainstorming methods, Delphi methods, interview methods, survey methods, and expert face-to-face surveys.

The Delphi method is a statistical method of reasonably deriving opinions from a group (Bright, 1978) and is widely used in a number of areas where expert groups can be utilized, such as technical demand and prediction, and is very useful when applying quantitative techniques. The purpose of the Delphi method is to identify new factors affecting the future situation of technology development, estimate probabilities for performance and realization timing prediction, use expert judgment to predict the timing of realization of future technologies without other methods, review the feasibility of technologies currently under study, and use them to measure activity levels subjectively and quantitatively when there is no objective data (Woundenberg, 1991).

The characteristics of the Delphi method can ensure anonymity by not informing experts of who participated in the process of carrying out the anonymous Delphi and who presented what opinions, by allowing them to exclude the influence of a reputable specific individual, to evaluate other differences on a fair basis, and to ensure self-assertion without any damage to social dignity or intimacy. Statistically aggregate the opinions of the entire quantification experts and present the distribution of the opinions of the entire group, such as the average or dispensing of opinions on each topic.

Typically, face-to-face (FTF) meetings are ignored in a way that reflects the majority opinion, but the Delphi method also applies to the minority opinion. In the modified response (feedback) Delphi, experts exchange opinions through a questionnaire, which the general research implementer aggregates the collected comments and informs the respondent again and gives them the opportunity to modify their responses. Always maintain and effectively achieve the original purpose by freeing a group of experts from the tendency to cling to an agreement itself to achieve or agree on an objective. The disadvantages of this Delphi approach are that it takes a long time to proceed, that it is difficult to obtain continuous support from the experts surveyed, that there are many problems with expert selection, and that it is likely to exclude important items presented by the experts in the preparation of the questionnaire.

Quantitative methods include the method of analysis of paper, patent information, score system model, principal component analysis, analyt5ic hierarchy process (AHP), Technical readiness level (TRL), technology level evaluation using patent index, and technology level evaluation method using technology growth model.

Analytic Hierarchy Process (AHP) is a systematic procedure that first classifies components of a problem into smaller components, with multiple alternative criteria for decision support, and each component represents a basic basis for subdivisions into smaller components, followed by a series of comparative judgements in which the decision maker compares them in pairs. The procedures and principles that will be used to determine the priority among the evaluation factors or criteria, and then to integrate these different judgments so that they can lead to the priority among the solution alternatives again, the numbers obtained by these procedures and principles are estimated on a ratio scale.

The hierarchy analysis process is divided into four stages. The first step establishes a decision-layer decision-making model by classifying decision problems into layers of interrelated decision-making items. In general, decision-making issues have the properties of multicomponent decision-making, often complex and interrelated, and to address these issues, they specify relevant decision-making elements-standards to form a hierarchical structure, and when planning or policy-making, they establish a more specific future (target) through a forward-looking, back-warding process, with a minimum implementation model composed of three-level, top-level objectives (Go). The second step collects judgement data as a bifurcation between decision elements, the third step is to estimate the relative weight of the decision element using the eigenvalue method, and the fourth step is to aggregate the relative weight of the decision factors to achieve the overall ranking of the various alternatives to be evaluated.

MAJOR DOMESTIC AND INTERNATIONAL CASES OF TECHNOLOGY LEVEL EVALUATION

In the U.S., the U.S. evaluated the location of U.S. technology on a five-point scale in Japan and Europe, and analyzed technological trends by dividing them into improvement, maintenance and degradation. The Bureau of Science and Resources Statistics under the National Science Foundation of the United States maintains and controls the science-related dynamics for the establishment of science and technology policies. The U.S. Center for Global Technology Evaluation conducts an international assessment of specific technologies through expert review and has published a report evaluating overseas research and development activities to provide global trends and information on science and technology to science and technology communities and policymakers.

In Japan, technical level surveys are conducted as preliminary research to establish a basic science and technology plan, and the main results are the "Research on R&D Level in Japan (Japan General Institute/ Science and

Technology Policy Institute 2000, "Benchmarking Research & Development Capacity in Japan" and "Study on Rapidly-Developing Research Area" (Science and Technology Policy Institute, 2005). Recently, the Science and Technology Promotion Organization under the Ministry of Education and Science conducted an international comparative survey (compared to the United State, Europe and China) of the number of papers/patents, the number of researchers, and the sales of related companies on the research level, technology development level, and industrial technology capabilities of Japan's five major science and technology sectors.

Following the discovery of technology development tasks through the technical demand survey in China, Delphi survey using experts was conducted to investigate technological gaps, R&D bases, means of technology development, scope of application of technology, practicality, market size, and time required for industrialization.

In Europe, the latest trends in consideration of growth, productivity and employment, which are key factors in the development of technological competitiveness, were reviewed to assess the level of Europe and the level of technology in major countries. The 'Major Figures on Innovation in Science and Technology' compared European Member States with the United States for the purpose of identifying major aspects of European member countries' investments and achievements related to knowledge economy.

The purpose of the survey of industrial technology level survey analysis (Korea Institute of Industrial Technology Evaluation: KEIT, 2006) is to investigate and analyze the level of industrial technology in all sectors of the industry (four sections, 44 divisions, 352 subdivisions, 874 core industrial technologies) to highlight current and future-oriented coordinates, while utilizing the data to support the direction of government support policies and strategic support areas') elicits; The survey outline refers to the important unit technology in the industrial technology classification system that belongs to a group, and as of the end of 2005, is a materialized technology that currently exists and includes all the technologies that have been put into practical use or under development. Key industrial technologies were selected in the first ('06. 4.11~5.10) survey, and the second ('06. 6.12~7.14~8.1~8.31) survey was conducted to investigate the level of industrial technology and to collect basic data for the comprehensive index of industrial technology. The second survey was conducted on 21,720 people, with responses of 4,670,533 respondents, respectively. Operate 44 industry (middle class) industry, academia and research expert committees ("May to June to June 2006) to verify and finalize core industrial technologies derived from the first survey, investigate and set weights for each core industrial technology, and consult with 10 industry-academic and research experts for preliminary and follow-up verification by major stages.

The methods of investigation and analysis of industrial technology level were analyzed by core industry technology and by large, medium, and small categories, and the compilation of core industrial technologies within the group used the Budget allocation method (budget allocation method) to reflect the differences in importance between core industrial technologies. The budget allocation method was further analyzed as an equal weighting method to enhance the feasibility of the industrial technology level survey by requiring experts to allocate the budget to each sub-index and express it as a weight, and the grouping and division aggregation were used by equal weighting methods.

CONCLUSION

This study grasps the definition and concept of technology capability and technology level, analyzes the technology level evaluation system and analysis method, derives evaluation indicators based on key domestic and foreign cases, analysis and expert opinions, and derives the technical variables and marketability of the derived variables. Analyzed whether competitiveness and influence have a significant relationship with current technology position. This study analyzes the characteristics of technology level evaluation, research the existing methods of technology level evaluation system and analysis method, so that a unit such as a country or a company can reasonably derive the evaluation of technology level possessed by the organization. The evaluation index can be derived by analyzing domestic and foreign cases. By establishing the basic direction of technology level evaluation through various methodologies and characteristics analysis of technology level evaluation, and establishing a methodology, technology level evaluation manual, and promotion system for this. A country or company practically connects with technology development strategy and R&D investment priority The emphasis was on contributing to making strategic decisions that could be made.

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