

**ORIGINAL RESEARCH**

# ANALYSIS OF THE KEY SUCCESS FACTORS FOR COMMERCIALIZING INNOVATION

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**Abstract**

The development and commercialization of new technologies have inherent uncertainties and associated risks. Many researches conducted by Indonesian R&Ds never reached the diffusion stage, i.e., the commercialization process. Therefore, Indonesia needs a strategy to translate promising technologies into a stream of economic returns for its stakeholders. This study analyzes the critical success factors (KSF) for commercializing innovation. It used new product development literature and TOE (technology–organization–environment) framework and developed a research model to investigate the determinants of commercialization of innovation. In choosing the selected vital success factors, a hierarchy of KSFs was defined. It also used the Analytic hierarchy process to help experts rank the importance of identified KSFs. The KSF hierarchy is constructed with two levels: a critical comprising three dimensions and a detailed level of nine individual factors. The result shows that the experts believe that in the top-level, technology is the most critical dimension followed by environment and organization. Technology is the primary consideration for the company before launching their product to the market. Market demand has the highest rank from the environmental dimension. Lastly, experts suggest that the organization network is the most significant to grasp investors and potential markets for successful commercialization.

**KEYWORDS:**

Author Guidelines, Literature Study, Original Research, Template

## 1 | INTRODUCTION

In the era of globalization, technological innovation is one of the main drivers of success in winning the global competition. Previous studies have reported that new products produced by new technologies have resulted in a 40% to 90% increase in national wealth in most countries. Indonesia is one of the developing countries that intensively emphasized technology as a part

of the sustainable process of their national development. Hill (1998) mentioned that Indonesia needs technology to sustain its economic growth<sup>[1]</sup>.

As mentioned in Indonesia's National Medium Term Development Plan or Rencana Pembangunan Jangka Menengah Nasional (RPJMN) 2015-2019, one of the government missions is to realize a competitive nation. This mission can be achieved through the development and application in the industry to produce competitive products. Therefore, the direction of Indonesia's national development 2015-2019 is to build a competitive advantage of the economy based on natural resources, qualified human resources, and the ability of science and technology. Indonesian government Ministry of Research, Technology, and Higher Education (RISTEKDIKTI) encourages domestic firms to build their technology by giving them Technological Incentives in Industry since 2015.

However, currently, Indonesia's competitiveness rating has declined based on the data from the International Institute of Management Development (IMD) in 2016. Indonesia's competitiveness ranking fell by 6th place, from 42th to 48th. Then according to the World Economic Forum (WEF) in 2016, Indonesia's rank dropped from 34th to 37th out of 140 countries. Another data, according to the Global Innovation Index (GII) in August 2016 Indonesia is at 88th position from 128th countries. This condition is undoubtedly a challenge for Indonesia, given the potential both in terms of natural resources and one of the largest populations in the world. One of the problems encountered, many research activities conducted by national R&D, only reached the alpha test stage (prototype development, replication and laboratory test) and beta (field test and further development) but not yet stages of diffusion. These diffusion stages are the resulting technology already implemented by the user, the initiation of commercialization, market development, and further commercialization. At this stage, various processes are required to meet the standards in accordance with market demand. The most challenging problem facing firms is how the new product or technology successfully commercialized, given a high level of market uncertainty. The experience proved that the commercialization of technology is potentially linked to levels of uncertainty and risk<sup>[2-6]</sup>.

Most studies have emphasized the significant role of market research, which includes market, customer, and competitor analysis in stimulating the need for a new product<sup>[7-9]</sup>. Despite the importance of this research subject, existing empirical results are often very varied and fragmented<sup>[10-12]</sup>.

Moreover, few efforts have been made to rank KSFs based on their relative importance<sup>[13]</sup>. This limited understanding is partly because of the complexity of the topic, and partly due to the researchers' choice of methodology<sup>[14]</sup>. Furthermore, previous research in this domain has tended to focus on the operations of large and well-established firms based in developed countries. It is unclear whether these findings would also hold in emerging countries such as Indonesia.

In this article, we aim to contribute towards simplifying the variations of the aforementioned success factors. This simplification is achieved by adopting a systematic approach using the Technology-Organization-Environment (TOE) framework and adapts its commercialization of innovation. In doing so, it offers an integrated view and conceptual guidelines for examining the determinants of success factors in the context of the high-tech industry<sup>[15]</sup>.

To achieve this goal, this study was conducted in three phases. In the first phase, a preliminary list of factors associated with the success of the high-tech industry was identified through a comprehensive literature review. These factors are further modified and validated through interviews with academicians and experts in the selected industry. However, these success factors are interconnected and cannot be treated as independent factors. Because of these interdependencies, the less critical factors may turn out to be more significant when evaluated collectively<sup>[16]</sup>. To address this issue, in the second phase, we propose the use of the Analytic Hierarchy Process (AHP) method to obtain the weight distribution of success factors and identify the KSFs.

AHP proves to be a practical approach for assessing the models with complex interdependent factors and provides a rigorous basis for addressing the problems involving both quantitative and qualitative factors<sup>[17]</sup>. AHP is a simple yet powerful tool that was first developed within the management science field over 20 years ago<sup>[18]</sup>. The relative weights of the KSFs obtained in the second phase are used as inputs for the third phase. In the last stage, we propose the results of AHP on KSFs as criteria for evaluating performance. The proposed approach is applied to two high-tech industries in Indonesia. The two selected high-tech sectors in Indonesia are pharmaceutical and petroleum.

## 2 | RELATED WORKS

In almost all cases, the successful innovation commercialization requires that the know-how in question be utilized with other capabilities or asset<sup>[19]</sup>. Key success factors use as a planning tool. The planning school aims at developing planning instruments which help businesses in finding the right strategy. The main assumption is that by providing input which helps decision-makers in structuring their thoughts, the quality of decision-making can be improved<sup>[20, 21]</sup>. Successful commercialization is crucial in transforming invention into innovation<sup>[22]</sup>. Based on prior research, a wide variety of antecedent factors can influence the outcomes of innovation activity. The diversity of research in this field includes marketing, organizational, behavior, engineering, and operation management<sup>[23]</sup>.

### 2.1 | Key Success Factors of Innovation Commercialization

In this part, we collected the previous study that mentioned success factors for innovation commercialization. After summarizing the factors, then we composed categories based on the TOE framework. Categorizing into the TOE framework is very helpful in many simplified factors presented from the previous study. As the ground theory, Project SAPPHO<sup>[24]</sup> is probably the first study to analyze successful commercial innovation by comparing between successful and unsuccessful innovations; after the study, the dyadic comparisons between project successes and failures have become popular to discover principal discriminating factors of innovation commercialization<sup>[17, 25]</sup>. The SAPPHO study found five main factors of commercially successful innovations, i.e., a better understanding of user needs, more marketing and publicity, work efficiently, use technology and scientific advice, and responsible individual.

Following the SAPPHO project, Cooper (1980) identified three success factors: the degree product uniqueness and superiority compared to existing alternatives. The second most important factor is market knowledge and the feeling of future market development. The third one is the synergy of the technological and manufacturing resource. Moreover, Teece (1986) indicated that services such as marketing, competitive manufacturing, and after-sales support were almost always needed for successful innovation commercialization. Cooper and Kleinschmidt (1987) further suggested that the market environment of new product success was determined by the new product strategy and development process execution. Additionally, the studies conducted by Montoya-Weiss and Calantone (1994); Henard and Szymanski (2001) and Van der Panne, et al. (2003) grouped various key success factors into multiple categories. Montoya-Weiss and Calantone (1994) categorize key factors into strategy, process, organization, and market. Henard and Szymanski (2001) categorize key factors into product, strategy, process, and market. Van der Panne et al. (2003) categorizes key factors into product, firm, project, and market.

For technology commercialization, technology competitiveness is the most important factor<sup>[26]</sup>. Balachandra and Friar (1999) pointed out that the more innovative technology is, the more likely is it to allow customers to do something beneficial through a greater breadth of technologies embodied in new products. R&D capability factors are also considered critical factors for improving the likelihood of new product success<sup>[26-30]</sup>. R&D capabilities factors are generally related to firms' resource allocation and organizational climate-related to the commercialization process. If the commercialization process and R&D organization are well-organized, the technologies used in the development of the project would also be widely available to the organization.

Souder and Song (1998) argued that organizational factors such as experiences, know-how, and professionalism of employees are related to the improvement of new product development capabilities. R&D employees should have a broad spectrum of experience and expertise in the design and implementation of new technology products.

Furthermore, management should enhance employees on R&D capabilities by creating a supportive climate that helps increase the innovation capability through rewards and internal support to employees. Managers set directions and develop clear commercialization processes that empower employees' productivity and competence in developing a new product<sup>[31]</sup>.

Based on the previous literature, technology and R&D capabilities should also be applied and adapted to improve the likelihood of success of new technology products. The two industries may have different characteristics of success factors. However, based on previous studies<sup>[23, 24]</sup>, many success factors in commercializing an innovation was conducted in multi-industry. It may be possible as the different industry competes for the same market or have the same characteristics. In this study, the pharmaceutical and petroleum industry carry the same characteristic, which contributes significantly to high-tech industry market performance in Indonesia.



**FIGURE 1** The TOE framework.

## 2.2 | TOE Framework

Tornatzky and Fleischer proposed the technology-organization-environment (TOE) framework in 1990. The framework, as shown in Figure 1, explained the complete process of innovation from the development of innovation by engineers and entrepreneurs to the adoption and implementation of those innovations from the aspects of technology, organization, and environment context<sup>[32]</sup>. The technological context refers to technological attributes relevant to innovation. The organizational context refers to the characteristics of the firm, including its size, its resources, and the complexity of its managerial structure. The environmental context refers to the arena in which a firm conducts its business; the arena in question may include the firm's belonging industry, its customers, its competitors, and the government<sup>[33]</sup>.

The TOE framework has a solid theoretical basis, consistent empirical support, and potential of the application, though specific factors identified within the three contexts may vary across different studies<sup>[34]</sup>. For example, Chau and Tam (1997) adopted this framework. They identified three factors that affect the adoption of open systems, namely, the characteristics of the innovation, organizational technology, and the external environment. Meanwhile, Borgman et al. (2013) used the TOE framework to investigate the factors influencing cloud computing adoption. In this study, the TOE framework is pursued to conceptualize and understand how IT governance processes and structures moderate those factors. Lastly, Pan and Jang (2008) considered the TOE framework to examine the effect of the decision to adopt enterprise resource planning (ERP) in Taiwan's communications industry by identifying factors that distinguish adopters from non-adopters. To construct the TOE framework, the considering factors concerning the successful innovation commercialization were deliberately drawn from a set of related theories and prior research<sup>[17, 23, 35]</sup>. Those factors are described in the following sections.

## 2.3 | Technological Context

The technological context represents the pool of technological attributes of innovation for its adoption. These can be both the technologies available to the market and the firm's' current technological assets. In other words, the decision to adopt an innovation depends not only on what is available on the market but also on how such innovation fit with the technologies that a firm already possesses<sup>[17, 25]</sup>.

The literature highlighted the importance of technology to the success of innovation commercialization. For example, Gatignon et al.<sup>[7]</sup> pointed out that the role of technology appeared unconditional; more is better in any kind of market, even in a stable market. Henard and Szymanski<sup>[35]</sup> and Van der Panne et al.<sup>[17]</sup> argued that technology was the nature of product innovation; Khademi and Ismail (2013) emphasized the technology employed in the process innovation development. Montoya-Weiss and Calantone<sup>[23]</sup> asserted the synergy between technology implementation and the strategic positioning of an innovation.

The technological context established in the current study has its origins in Innovation Diffusion Theory (IDT)<sup>[36]</sup>. The IDT proposes five perceived attributes of an innovation that influence its adoption: relative advantage, compatibility, complexity, trialability, and observe ability. However, empirical studies have indicated that, of these five attributes, only relative advantage, compatibility, and complexity are consistently related to adoption or utilization decisions<sup>[7, 37, 38]</sup>. These three common attributes are echoed by prior innovation commercialization research. How relative advantage, compatibility, and complexity of an innovation related to the innovation commercialization is explored as follows.

## 2.4 | Relative advantage

Relative advantage is defined as the degree to which an innovation is perceived as better than the idea it supersedes<sup>[39, 40]</sup>. These attributes are often expressed in economic profitability, in status giving, or other ways. The nature of the innovation largely determines what specific type of relative advantage (such as financial, social, and the like). Relative advantage relies on the matter of individual feel the innovation give benefits, The higher the perceived relative advantage of innovation, the more rapid its rate of adoption is going to be<sup>[39]</sup>. Relative advantage appears as a consistently important characteristic for innovation success.

A large-scale meta-analysis study by<sup>[23]</sup> showed a significant correlation between successful commercialization and the advantages of innovation. Consumers need to be convinced of the potential benefit of innovation<sup>[39]</sup>. New products that are more continuous, product superiority is relevant for success, although it probably needs to be less overwhelming since customers face a much lower purchase risk<sup>[39, 41]</sup>. In the services industry, the need for product superiority or distinctiveness has also been shown to be an essential success criterion<sup>[28, 42, 43]</sup>. For discontinuous service innovations, interaction with clients offers an opportunity to explain and convince customers of the value embodied in a new and unfamiliar service; for incremental products, highlighting on providing customers with a more satisfying experience; for example, offering more efficient problem solving, improved client training, or a more professional working relationship can be an essential basis for differentiating the new service from competitive<sup>[44–46]</sup>.

## 2.5 | Compatibility

Compatibility is the degree to which an innovation is perceived as consistent with existing values, experience, and the needs of potential adopters<sup>[39]</sup>. Liu et al.<sup>[47]</sup> contended that an innovation diffuses more easily where such innovation appears to match the adopter's existing processes. Previous studies on innovation commercialization indicated that compatibility was one of the key factors that prevent innovation failure<sup>[17, 39, 47]</sup>. The more compatibility the innovation with existing values, experience, and needs, the faster the adoption tends to be.

Other authors hold that compatibility is one of the key of market attractiveness and a precise definition of a customer need(s)<sup>[42]</sup>. The new or emerging technologies usually take a long time to develop to the point where they solve customer problems<sup>[48, 49]</sup>. Compatibility is one of the key points to win the market. Technologies which are incompatible with customer values, system, and consumption pattern leads to purchase risks, particularly when the ultimate direction of the technology is unclear<sup>[49]</sup>. In the business-to-business sector, customer organizations that are responding to the need for cutting-edge innovation before the majority of the market accept the innovation can play an important role in the ultimate success of these types of new products<sup>[43, 50]</sup>. New products that are adaptation, refinements, and enhancements of existing products and/or delivery systems are often better performers because they build on established product platforms and because they leverage the known resources, skills, and identity of the firms<sup>[51]</sup>.

## 2.6 | Complexity

Complexity is the degree to which an innovation is perceived as relatively difficult to understand and use. Any innovation may be classified on the complexity-simplicity continuum. Complexity typically indicates a slower innovation adoption rate<sup>[52, 53]</sup>, and may also create disutility through "feature fatigue"<sup>[54]</sup>. In the process of innovation diffusion, and innovation with complexities often entails potential customers to invest significant effort in learning to achieve promised benefits. Some individuals resist innovation because of their reluctance to undergo the necessary adjustment period. When people are confronted with a new product/service and are requested to undertake learning tasks to adopt it, the new task stress and the perception of less control over their lives produce resistance to innovation in concern. Specifically, innovation resistance occurs when consumers perceive the expected learning task as complex and difficult for innovation<sup>[55]</sup>. The results of empirical research indicate that 41% of

firms observe no return on their innovative products. In comparison, 48% of potential consumers delay purchases, and 30% of consumers return purchased technological innovation products due to consumer perception of product complexity.

These empirical studies reveal that a significant proportion of innovation commercialization failure resulting from the complexity of innovation. Rogers thus reiterated that an innovation's complexity could function as an inhibitor and is usually negatively related to innovation diffusion<sup>[39]</sup>.

## 2.7 | Organizational Context

The organizational context represents the factors internal to an organization influencing an innovation adoption and implementation<sup>[15]</sup>. The organizational context refers to the characteristics and resources of the firm, including linking structures between employees, intra-firm communication processes, firm size, and the number of slack resources<sup>[32]</sup>. Organizations play an important role in introducing innovation to the market. Sivadas and Dwyer<sup>[56]</sup> made their study comparison of organizational factors influencing new product success in the semiconductor and healthcare industry. Their study results show that new product development success is positively related to internal organization support among R&D, marketing, manufacturing, and management support.

The success of the commercialization of innovation depends on the firm's new product strategy<sup>[28, 57]</sup>. In the case of highly innovative new products, it is their strategic fit which is essential as these ventures not only determine the firm's business success over a long run but considerably stretch its vital and scarce resource<sup>[12, 23, 28, 51]</sup>.

Another company-related success factor has to do with the type of innovation development culture that permeates the firm. Creating an entrepreneurial and team-oriented climate, with strong support and involvement from top management, is considered important for facilitating successful innovation by firms<sup>[30, 58]</sup>. For a highly innovative new product venture, top management involvement is essential<sup>[48, 49]</sup>. Great management is empowered to move things forward quickly and effectively by activating functional involvement and minimizing expendable steps<sup>[23, 59]</sup>.

This study chooses the following three organizational factors since they are widely referred to by prior research works<sup>[17, 23, 35, 56, 60]</sup>. They are organization culture of innovativeness, organization resource, and organization networking. These factors are highlighted because they significantly related to the success of innovation commercialization.

## 2.8 | Organizational Culture of Innovativeness

Organizational culture is the pattern of the underlying assumption that a given group has invented, discovered, or developed in learning to cope with its problems of external adaptation and internal integration. It is widely recognized that innovation culture is related to increased organizational performance<sup>[48]</sup>. A firm with innovativeness tends to promote change, creativity, and novelty to develop new products and processes<sup>[61]</sup>. Trot<sup>[62]</sup> explained that long-term economic growth for a firm depends on the innovation capability. The development of innovation capability requires creativity and room to try out new ideas. This is usually accomplished in a cultural environment that explicitly recognizes the collective nature of innovation efforts. Empirical studies show that a firm's culture that is dedicated to innovation<sup>[17]</sup>.

From a macro perspective, a firm with innovativeness encompasses the capacity of innovation to create a paradigm shift in an industry. From a micro view, a firm with innovativeness can be seen as the capacity to influence the firm's existing marketing resources, technological resources, skills, knowledge, capabilities, or strategy<sup>[60]</sup>. For several reasons, a firm with strong innovativeness can drive innovation strategy that leads to successful innovation commercialization. First, innovativeness provides a guideline for dealing with strategic issues, such as selecting the markets to enter and the required skills to develop. Second, innovativeness enables a firm to take advantage of the synergy between parallel innovation projects. Third, learning-by-doing can materialize the firm reap benefits of previously successful innovations and firm-specific skills that emanate from them<sup>[24]</sup>.

## 2.9 | Organization Resources

The Resource-Based View (RBV) is a well-known theory to determine the strategic resources available to a firm. The RBV asserts that firms sustain competitive advantages by deploying valuable resources that are superior, scarce, and inimitable<sup>[63, 64]</sup>. It includes capital, manufacturing facilities, and workforce requirements<sup>[23]</sup>. Commercializing an innovation not only requires tangible organization resources such as capital, manufacturing facilities, and financial resources but intangible ones, including



technical competence, the experience of the industry, market knowledge, and close relationship with customers<sup>[65]</sup>. The more resources a firm allocates to innovation activities, the more likely it is to achieve successful innovation commercialization<sup>[10, 66]</sup>.

For incremental new products, resources and strategic fit are also important. An excellent resource fit can lead to more efficient, error-free, and often more highly leveraged innovation; an excellent strategic fit is essential for planning and introducing innovation in which the firm can sustain its competitive advantage<sup>[67]</sup>. Particularly in cases where services rely on distinctive, company facilities or resource, for example, a major operating system or a specialized team of experts; a high degree of fit can be incredibly advantageous from a cost, profit, and new product adoption perspective<sup>[42, 68]</sup>.

## 2.10 | Organization Networking

Organization networking refers to the organization's pattern of relationships with other organizations in the same network<sup>[69]</sup>. The role, development, and performance of companies is described by their ability to develop relationships. The actors in a firm's networking include distributors, buyers, suppliers, research institutes, competitors, government agencies, industry associations. It has been widely acknowledged that networking plays a crucial role in the innovation commercialization route<sup>[70-72]</sup>. Diverse networking actors contribute to innovation commercialization in different ways<sup>[73]</sup>. For example, vertically related networking actors, such as customers, suppliers, and distributors, help a firm to stimulate innovative ideas and implement them. The horizontal actors, such as research institutions or partners beyond the traditional supply chain, facilitate bringing innovations to the market<sup>[74]</sup>.

Network relations could give the firm access to other firms' resources as complementary resources for innovation commercialization. Therefore organizational network means firms may create future demand and new market by integrating their complementary resources, products, and channel relationship through networking<sup>[74]</sup>. Sharing resources and expertise to develop new products, achieve economies of scale, and gain access to new technology and market is the weapon to face the fierce competition<sup>[62]</sup>. Networking activities may serve as a basis for selling innovative products to customers with whom the company is not collaborating technologically. Network competence contributes to a company's innovation success directly, not only through increasing the degree of technological interweaving<sup>[50, 65, 73]</sup>. The rationale behind the positive impact is that through collaboration, more resources can be utilized in the development process, i.e., more personal power, a larger pool of technological facilities, larger quantity, and increased quality of information and ideas. Also, more innovation projects can be carried out due to more resources, which reduces the negative impact of failing individual developments<sup>[74]</sup>.

## 2.11 | Environment Context

Environmental context is the external arena in which a firm conducts its business. The literature has identified several elements that contribute to environment context<sup>[15, 17, 35]</sup>. Among all environment-related factors, the current study deliberately chooses three, i.e., market demand, competitive pressure, and government policy. These factors are chosen due to their significant results and the highest number of citation from previous studies<sup>[17, 23, 35]</sup>.

## 2.12 | Market Demand

Market demand refers to the presence of consumers with different needs and requirements on firms' innovation choices. Therefore, strong market demand is the prerequisite of any commercialization activities<sup>[7]</sup>. Based upon an examination of some 567 innovations in five different industries, Myers and Marquis (1969) concluded that "recognition of demand is one of the most frequent consideration factors in innovation opportunity recognition." Cohen and Levin (1989) argued that market demand is more fundamental than other elements such as firm size or market concentration to achieve successful commercialization. Table 1 shows the factors considered for innovation commercialization.

Customers perceive the value of a product differently. The market demand is varied and heterogeneous. Hence, firms must understand their target customers and anticipate the dynamic preference of customers to meet market demand rapidly. In McGrath (1997), it is stated that a firm can test the market demand of an innovative product by asking the following questions: is there a need existing but not being satisfied by current products? Is the need prevalent? Does the innovative product that my firm develops satisfy the need? If yes, the higher the market demands, the higher value of the innovative product

**TABLE 1** Commercialization of an innovation consideration factors.

Dimension	Factor	Definition
Technology	Relative advantage	The degree to which an innovation is perceived as being better than its precursor.
	Compatibility	The degree to which an innovation is perceived as being consistent with existing values, past experience, and the needs of potential adopters.
Organization	Complexity	The degree to which an innovation is perceived as being difficult to understand and use.
	Organization culture of innovativeness	A firm culture that promote change, creativity and novelty in order to develop new product and processes.
	Organization resource	All of firm's assets and organizational attributes including knowledge and processes controlled by them.
Environment	Organization networking	The focal organization's pattern of relationships with other organizations in the same network
	Market demand	The presence of consumers with different needs and requirements on firms' innovation choices.
	Competitive pressure	The intensity of competition coming from the same domain that a firm in practice related to price, quality, service, or the salesforce or distribution system.
	Government policy	The rules set by government to impact a firm's innovation policy.

### 2.13 | Competitive Pressure

Competitive pressure refers to peer pressure coming from the same domain as a firm in practice. It reflects the intensity of competition in the marketplace concerning price, quality, service, or the sales force or distribution system<sup>[23]</sup>. Competitive pressure has long been recognized as a driving force of innovation; it further presses a company to seek a competitive edge through the success of innovation commercialization<sup>[7]</sup>

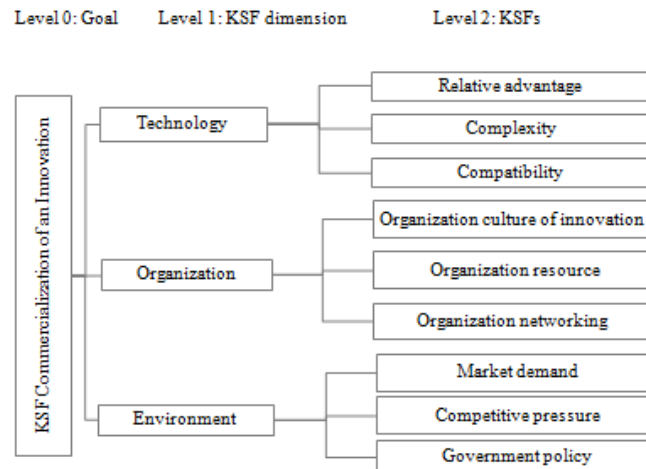
Firms gain a competitive advantage in international competition through improvement, innovation, and upgrading. The commercialization of emerging technologies is characterized by intense competition in innovations. There is usually a substantial advantage to be the first innovators when the first mover's advantages are significant, and when the patent preemption is likely. Competition accelerates obsolescence and the rate at which innovators are disseminated, thereby curtailing their expected commercial lives and destroying their appropriable value. Past studies have assumed that if there is no competition in innovation activities, the state of the art of today's technological progress in the future, and that the proprietary rights of current technologies are guarantees forever.

### 2.14 | Government Policy

Government policy is a powerful force to impact a firm's innovation policy<sup>[33]</sup>. Innovation policies can emphasize basic research and technology development (e.g., public funding of basic research), exploitation of research infrastructure (e.g., university-industry collaboration), support of industrial technology development (e.g., tax subsidies for R&D), technology adoption, and technical standardization. Government authority attempts to create an environment conducive to innovation through legal mechanisms such as tax codes, patent law, and antitrust regulations. The government, primarily at the national level, provides technology infrastructure that leverages the innovation process. Through its actions providing technology infrastructure, the government supports mechanisms, institutions, and platforms to lessen innovation barriers that cause market failure for investments in all stages of technology-based economic activity<sup>[75]</sup>. Technology policy was defined as policies that are intended to influence firms decisions to develop, commercialize, or adopt new technologies. Innovation policy refers to policies intended to influence public and private organizations' behavior in the development and commercialization of new technologies.

Governments have taken various policy measures to promote innovative activities to reap economic and social benefits from technological progress<sup>[76]</sup>. There is a tendency in many countries that the government authorities seek to nourish innovations by means of establishing science parks and business incubators. Whether such parks and incubators are the results of a "natural" outgrowth of research centers or spin-offs from incumbent enterprises, the phenomenon has shaped an important mode of innovation commercialization<sup>[42]</sup>. The example of government policy that successfully supports innovation commercialization is in U.S Small Business Innovation Research (SBIR) program. In the SBIR program, the government provides financial capital,





**FIGURE 2** The two-level hierarchy of the key successful factors for innovation commercialization.

is a decision-maker, is an organizer and coordinator of economic resources, and is an allocator of resources among alternative uses.

### 3 | MATERIAL AND METHOD

Thomas L. AHP originally devised the Analytic Hierarchy Process (AHP) is a structured technique for organizing and analyzing complex decisions based on paired comparisons of both projects and criteria. These inputs are converted into scores that are used to evaluate each of the possible alternatives.

The AHP is a powerful management science tool that has proven useful in structuring complex multi-person, multi-criterion decisions in business and economics. The advantages of AHP to the user include its reliance on easily obtained managerial judgment data, its ability to reconcile differences (inconsistencies) in managerial judgments and perceptions, and the existence of easy-to-use commercial software (i.e. "Expert Choice") that implements the AHP<sup>[23]</sup>. The strength of the AHP method lies in its ability to structure complex, multi-person, multi-attribute, and multi-period problem hierarchically. Thus, it has been discussed in a wide variety of decision situations in fields such as business planning, resource allocation, priority setting, and selection among alternatives. This AHP method can give reasonable approximation when the decision maker's judgments are consistent.

The first stage is grouping the success factors from previous studies<sup>[17, 19, 23, 24, 28, 35]</sup>, and put their success factors into TOE framework. The process of choosing the dimension involved scholar opinions. The following three questions were asked to the expert:

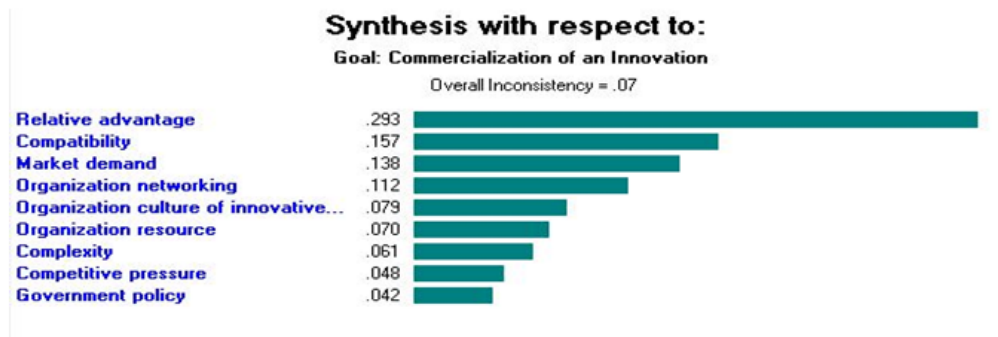
**Q1** Which KSFs do you think are more appropriate for the commercialization of an innovation?

**Q2** Which KSFs are fractional but related enough to be combined into one?

**Q3** Which KSFs are similar and can be grouped into categories in light of TOE?

#### 3.1 | Research Survey

Figure 2 shows the hierarchy of KSF for innovation commercialization. The hierarchy is designed as two-level hierarchy. Inline with the hierarchy, we designed a questionnaire complying with the AHP format. The questionnaire was distributed to 16 selected members from 2 companies; 8 marketing experts from PT. Pertamina, which represents the petroleum industry in Indonesia and eight marketing and promotion experts from PT.Bio Farma represents the pharmaceutical industry, and all members had more than ten years of working experience in their industry. The chosen members have been working in the industry for at least more



**FIGURE 3** The consistency ratio from AHP result.

**TABLE 2** Weights and ranks of the six criterion groups and 22 sub-criteria.

Criteria	Local Weight	Rank	Factors	Local Weight	Global Weight	Rank
Technology	0.539	1	Relative advantage	0.573	0.309	1
			Complexity	0.119	0.064	5
			Compatibility	0.308	0.166	2
Organization	0.207	3	Organization network- ing	0.430	0.089	4
			Organization culture of innovativeness	0.301	0.062	6
			Organization resource	0.269	0.056	7
Environment	0.254	2	Market demand	0.608	0.155	3
			Competitive pressure	0.210	0.053	8
			Government policy	0.183	0.046	9

than eight years. The two companies are chosen based on their performance and reputation as a successful high-technology based industry in Indonesia.

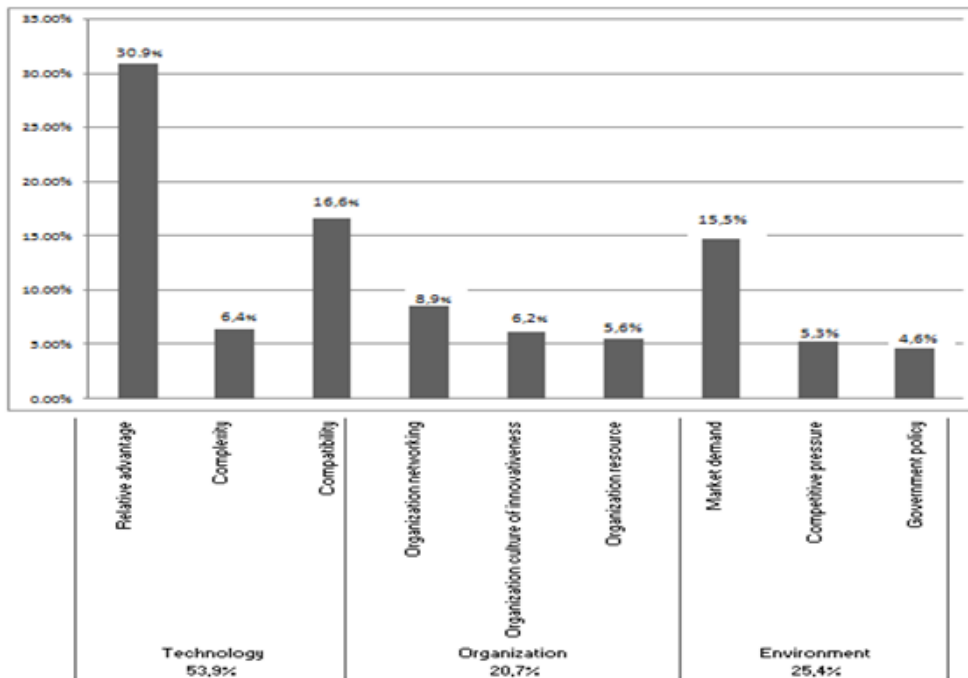
The survey was conducted for approximately four months, starting from March to June 2018. Initially, we submitted a research proposal to be reviewed by both companies. The official proposal was sent via email. Furthermore, the questionnaire was given directly to both companies in Indonesia. Correspondence was done face to face, via phone also via email. Results from the questionnaire were sent gradually over two months via email. The survey allows the selected members to give the relative importance ranking of the aforementioned KSF each dimension and factors.

## 4 | RESULTS AND DISCUSSION

After the pair-wise comparison process is completed, and an initial decision matrix is achieved, the initial matrix is normalized. As shown in Figure 3, in this study, overall CR is 0.07, which fell within the acceptable level of 0.10, as recommended by Saaty<sup>[18]</sup>. This shows that the survey respondents have assigned their weights consistently after examining the priorities of success factors of commercialization for new technology products

As shown in Table 2, the criterion group of technology has the highest rank, weighing 53,9%. More than half of the weight falls into the technology factor. This result is relevant to prior research. In the successful new product commercialization, technology is one of the most commonly cited success factors<sup>[26]</sup>. Environment factors rank below the technology factor with 25,4%; this shows that environmental factors also embodied significant role for a successful new product, supported by a literature review that emphasized the significant role of the market research, which includes market, customer, and competitor analysis in stimulating the need for a new product. Most of the literature pointed out the impotence of product technology and market demand and put the organization factors below these two factors, which explained why the organization factor placed third among the TOE framework with 20,7%.

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**FIGURE 4** Histogram of weights against 9 sub-criteria in 3 criterion groups.

The results of our analysis could provide an assessment framework for the commercialization of new technology products. We suggest a new technology product assessment model that can be practically applied by experts to minimize the market and technology uncertainties and to increase the decisions' effectiveness. The criterion group of technology has the highest rank, with weighting 53,9%. It suggest that in the successful new product commercialization, technology is one of the most commonly cited success factors.

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This result can also explain in the technology-driven product. Where innovation has been induced by technological capability rather than expressed market need, the concept of technology-push applies<sup>[34]</sup>. For years, scholars have argued about two kinds of successful market-driven; technology-push and demand-pull<sup>[50]</sup>. Market-pull driven strategy predominates because they aim to improve existing product lines according to consumer market trends. Most technical innovations were driven by science and technology, the role of demand, and more broadly of the market and social forces were complementary in that respect.

However, more recent studies believe that many technological innovations have their origin in science and technology but still need a market and the related complementary assets to be successfully commercialized. It is assumed that both strategies, technology push, and market pull, are equally important to all kinds of organizations. It is believed that 'technology-push' and 'demand-pull' are complementary, rather than contradictory, factors determining the success of innovation. This study found

that alongside technology factors (relative advantage and compatibility), environmental factors (market demand) also received a higher score than remaining factors.

The overall result shows that Technology's factors are more appealing in Indonesia's high-tech industry than Environment factors like market demand. This can be explained by the light-emitting diode (LED) lighting in Korea as an illustrative example because it coincides with features of companies adopting the technology-push strategy. Most consumers may be ignorant about laser medical devices because the specifications of the relevant technology embodied in products are challenging to understand, such as principles and components. Because it is challenging to acquire customer requirements, new product development is led not by customer needs but, instead, by advances in technology and inventors. Although the proposed approach is based on technology, and consumers are not familiar with technology, they would be closely associated with technology. Potential and possible concepts of products and markets are extracted from the technological specification. Thus, firms in the solar LED lighting field easily choose a technology-driven strategy more than a market-pull strategy for their R&D planning.

The results of this study might give more insight for managers to have a better strategy for successfully launch their new product, especially in the Indonesian market. The top-level of the KSF hierarchy, within the technology dimension, the success of new product commercialization depends heavily on the relative advantage and compatibility of the product. Firms must be able to convince the market that their new product gives advantages over other available products<sup>[39]</sup>. The new technologies also have to be compatible with Indonesian customer value. Compatibility is one of the key points to win the market. Ease of use of the innovation facilitates its diffusion and speeds-up its adoption. Running trials reduces customer uncertainty and reinforces positive attitudes, and thus eases adoption<sup>[9]</sup>. Customers evaluate the relative advantage and therefore need to be convinced about the potential benefits<sup>[39]</sup>. The more observable such benefits are, and the more compatible the innovation is with existing values, experiences, and needs, the faster the adoption tends to be. Other than the relative advantage and compatibility of the product, this study shows that the market demand factor is nearly as crucial as product compatibility. Firms must understand that consumer needs are subject to change over time, as are the specific ways in which consumers seek to satisfy these needs through the purchase and consumption of particular products ('demand'). Such changes may occur as a result of demographic, socio-economic, and cultural changes in society.

## 5 | CONCLUSION

This study aims to analyze the critical success factors for commercializing innovations produced by R&D in Indonesia. It used TOE framework to investigate the determinants of innovation commercialization. The results of our analysis could provide an assessment framework for the commercialization of new technology products. We suggest a new technology product assessment model that can be practically applied by experts to minimize the market and technology uncertainties and to increase the decisions' effectiveness. As shown in Figure 4, the criterion group of technology has the highest rank, with weighting 53,9%. In the successful new product commercialization, technology is one of the most commonly cited success factors.

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