Formulation of research and development strategy in power plant equipment's manufacturing industries

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Application of advanced technologies in the production process has continuously made power plant equipment's manufacturing industries to move beyond the borders of knowledge and technology. What expedites this movement is R&D[1] which involves organizational resources and aligning with goals and strategies. Proper selection of R&D projects requires an appropriate strategy in line with the business goals of companies operating in this sector. To identify factors affecting R&D strategy formulation, we reviewed existing literature. Then a questionnaire was made using perceptions of 18 academic experts working in R&D departments. The questionnaire was confirmed in terms of validity and reliability and then distributed among experts of 10 companies active in R&D. Findings from structural equation modeling in Smart PLS software revealed that 23 established indicators affect R&D strategy formulation. The indicators were lied and prioritized in six main drivers including business strategy, technology strategy, R&D collaboration strategy, R&D funding strategy, innovation strategy, and R&D supportive strategy, respectively. The results show all the extracted factors have a significant impact on the formulation of R&D strategy. Policymakers should consider each of the great six factors when formulating R&D strategy.

keywords: *R&D, Strategy, R&D strategy, Power plant equipment's manufacturing industries.*

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1. INTRODUCTION

Certainly, in today's world of competition, the incessant contribution of innovative products and services connected to the customers' desire and taste is accounted as a prerequisite of a business organization's survival. Globalization of the economy has resulted in the expansion of investment, financial, and also technological exchanges in the global arena. One of the major consequences of globalization is the increase in foreign direct investments. This has made local customers more accessible to markets and global manufacturers and increased customer awareness. Development of communication technologies as well as information and social networks have formed the "global village". In such a position, organizations will have to constantly revolutionize products, processes, and services to compete and survive in world market conditions. One of the most effective ways to succeed sustainable innovation is to engage in R&D activities. Frascati manual defines R&D as creative and systematic work undertaken to increase the stock of knowledge—including knowledge of humankind, culture, and society—and to devise new applications of available knowledge [1]. R&D activities should focus on the best opportunities, that create a new business or transform the entire business of the organization [2].

The Complexity of the innovation process and technological progress on the one hand, and the limited resources of organizations as well as the need for proper allocation of resources-to prevent their waste-on the other hand, necessitate formulating appropriate organizational strategies. The goal is to develop a strategy for mobilizing resources to partake into the competition. Nowadays, the characteristics of innovative activities have been changed as a consequence of technological innovations. The cumulative nature of technological capabilities, more specialized technical activities, and the uncertainty associated with the development of technology have a profound impression on technology-related decisions. This challenges technology decision-makers. Easy access to low-cost oil and gas reserves, increased gas production, and industrial growth have intensified the demand for electricity consumption. Furthermore, high-elastic markets in adjacent countries, desirable technological capabilities, low dependence on imported technologies, and the existence of appropriate infrastructure for development of the power plant industry, may be considered as the strengths and opportunities ahead for the development of Iran's electricity industry. Regarding the annual growth of electricity consumption, projections show a 6% annual growth of demand for electricity generation in Iran. This stands for an annual increase of about 5000 MW of installed capacity, as well as annual investment of three billion euros on the electricity generation [3].

Association of the electricity network with adjacent countries, proved reserves of natural gas and crude oil, expertise in construction and operation of power plants, and growing electricity demand in countries such as Iraq, Turkey, Pakistan, and Afghanistan have characterized Iran's electricity industry. These attributes reinforce the power plant sector to be accounted for as an industry with reliable and sustainable upcoming growth.
China and the US rank first and second-largest electricity producers and consumers in the world, with capacities of 1,100 and 1,053 GW, respectively. These country pair account for about 40% of world electricity capacity. From global electricity market points of view, Iran ranks as follows [3]:

- 14th (following South Korea) in terms of installed electricity capacity.
- 19th (next to Turkey) in terms of electricity consumption.
- Eighth (after Mexico) in terms of electricity waste.
- Ninth (following Ukraine) in terms of electricity exports.

The growth opportunities of power plant industry in lights of domestic demand and high elastic markets of neighboring countries unveils the importance of investing on this industry. Power plant equipment's manufacturing industry plays a critical role in the supply chain of the electricity industry. However, technologies available in this sector are complex. This exaggerates companies engaging in this sector to pay much special attention to R&D.

At a glance, history of the power plant industry reveals that in the first half of the 2000s, the production of power plant equipment in Iran was so high that it provided some kind of autarky. Following construction of capabilities, the next step is to optimize products according to customers' demands and reduce the costs associated with operation and maintenance. To this end, investments and formulation of R&D projects are compulsory. Furthermore, regarding the existing international atmosphere, technology transfer from international supply sources will be more difficult; because domestic capabilities are in a way that discourages suppliers from being exposed to a potential rival. Over the past years, large-scale power plant equipment manufacturing companies such as Mapna and subsidiaries have experienced a stage in technology growth. They have passed phase of optimizing existing technologies and are entering into the development of new ones. Accordingly, the importance of formulating appropriate R&D strategies that are properly coordinated with the business strategies of these companies becomes more apparent. The prominence of this industry and the government's support should be directed by appropriate R&D and corporate strategies. This maximizes the use of allocated resources and meets the macroeconomic goals of Iran's electricity industry to provide appropriate industrial development infrastructures, as well as exports to regional emerging markets. The target in the Mapna group on the horizon of 2019 is to grasp the level of compulsory knowledge to develop new products [4].

This study aims to provide a clear picture for the required priorities of decision making in the power plant equipment sector. To this end, we investigate existing specialized literature and perceptions of academic experts based on Structural Equations Modeling. This issue has not been addressed so far. Therefore, no model has been presented to prioritize factors affecting R&D strategies.

2. REVIEW OF LITERATURE

Gary Pisano states that organizations respect the innovation as an instrument to improve their performance [5]. From an international competition environment point of view, organizations should admire R&D as a catalyst for innovation empowerment regardless of whether they are an advanced technology organization such as pharmaceutical firms or middle-class technology, such as automotive. The failure of organizations to take advantage of R&D does not refer to a lack of top management sponsorship, but the main underlying cause drives from a confusion of R&D pros and cons that affect the proper functioning of R&D. Unfortunately, there is no fitted and internationally incorporated R&D model, and the current mockups are influenced by various decisions and choices. He also describes the four main components of the R&D strategies as follows:

- Strategy architecture, including centralizing or decentralizing R&D activities.
- Processes, including development as well as decision-making processes and process indicators.
- R&D workforce, including specialists and other affiliated personnel.
- A portfolio of R&D projects, including the characteristics of the projects and the ideals.

But how R & D strategy should be formulated is what Cazares takes into account by scanning the behaviors and decisions of innovative companies through analysis of internal resources, industry characteristics, and favorable conditions as a driver to choose an R&D strategy [6]. He points out that this strategy takes one of three combinations, buying, making, and/or both. Investigating the 1539 companies between 1992 and 2005 and the study of technological resources, size, and scope of the organizations, show companies having tailored corporate resources and competitive positions in the market, generally select to buy the R&D results. In contrast, companies that have significant technology resources and are operating in high-tech industries prefer to use making strategy in the R&D sector. Andreas Larsson examined factors influencing the R&D strategies formulation in order to explore how to model and integrate an R&D strategy with support organizational strategies [7]. He concentrated on the R&D process and its connections with the business strategies of the organization. The proposed model has been developed concerning the strategic plan of the organization, the R&D process, the new product development strategy, risk management, and the portfolio of R&D projects. It should be also noted that one of the key factors in the successful implementation of a strategy is the faithfulness and stability. Andersson verified two hypotheses to examine such importance. The first hypothesis states that R&D strategy and its stability will enhance the opportunities for entrepreneurship in trustworthy organizations. The second hypothesis implies that R&D strategy and its stability increase the success rate of entrepreneurial opportunities in credible organizations [8]. He also set up variables and ratios such as sales to personnel, value-added to personnel, the ratio of export to sales, inherited knowledge capital, size of the organization and the level of technology and concluded that organizations in which R&D play a significant role, are less likely to spawn entrepreneurs but the entrepreneurial opportunities of these companies have a higher quality. Pereira scrutinized the impact of R&D on startup companies through analysis of 818 startups from 2004 to 2010 [9]. He considered the intensity of R&D and its connections with the growth and the total number of patents recorded during the period and concluded that the intensity of R&D and licensing contracts affects the growth of startups, significantly. Laleh scanned R&D capability indicators in BRICS [1] countries and studied capability assessment approaches from several perspectives in the underlying countries [10]. Finally, the proposed model includes factors such as staffing, training, laws, and regulations, as well as R&D strategies. Mansoori & Yavari investigated different patterns of R&D strategy formulation, including smart model, growing pattern, and integrated model based on strategic reference points [11]. They emphasized on linking the R&D strategy to the business strategy of the whole organization.

One of the core factors in the success of R&D activities is the timely and appropriate investment, and this plays a critical role in shaping the R&D strategies. Taewon Kang points out the persistence and volatility of firm R&D investment have been popular research subjects for the R&D management field [12]. Although the previous studies have found mixed evidence concerning the persistency and volatility of firm R&D investment, it depends on a variety of factors, including the intensity of R&D, the ratio of researchers to total personnel, and the sales volumes. It should be noted that the technological and positive and negative market shocks also affect the investment results. The amounts of capital devoted to the R&D projects are determined in some different ways. Wang Ruiqi inspected the relationship between R&D costs and the ongoing performance of organizations. The 772 Chinese sample firms were surveyed in this research from 2007 to 2012 [13]. The examination of future performance variables of the organization, as well as R&D costs, main owner and his/her authorities, the past performance of organizations, registered patents, capital, operating costs, size and scope of organizations addressed a positive impact of R&D costs on the performance of sample firms. Babkin while evaluating the effects of innovation strategies and R&D costs on the performance of IT companies, argues that innovation is highly dependent on the introduction of new products to the market [14]. He scrambles to determine the mechanisms for choosing the appropriate innovation strategies and proper estimation of R&D projects. Based on the data variables including total income, profit, capital, and R&D costs, the correlation between innovation strategies and organizational performance is confirmed. Jose Mata examined the impact of in-house and outsourced R&D strategies on the return on investment distribution function [15]. He concluded that outsourced innovation increases the median of organization profit, but also increases the skewness and kurtosis of the organization's profit function. This implies that outsourced innovation strategies are risky and require a lot of effort to gain an average return on investment. This will leave smaller companies with high unpleasant risks. Contrary to the initial evidence, the results did not support the direct effect of outsourced innovation on the organization's profitability skewness. The research variables include in-house R&D, outsourced R&D, level of education of personnel, as well as the size of organizations. The results also indicated the outsourced strategies of innovation improve profitability. Profit resources, in this case, are more dispersed. These denote the probability of organizations is higher in the case of outsourced innovation strategies and organizations are required to pay attention to both sides of the profit distribution function.

Due to the limited resources of the organization, R&D investment should enhance performance. Vanderpal surveyed variables such as income, capital, return on investment, net income, and the ratio of R&D costs to the operating income and observed that investment on R&D rather than tangible assets has a twofold impact on the increase in market share and positively affects income growth [16]. Peter Teirlinck, illustrates the relationship between strategic decisions taken in R&D over the 2009 financial crisis by corporations and the subsequent impact of these decisions over 2010 to 2013 [17]. The study is focused on SME's R&D decisions. The aspects of this decision include absorption capacity, open innovation, types as well as the structure of R&D activities. Research variables include financial performance, R&D intensity, R&D costs quota (especially for the development), as well as organization age and size. Di Cintio, analyzed the growth rate, employment, and intensity of R&D in the Italian SMEs, and concluded that R&D costs increase employment and payment to the labor force [18]. The large and multinational corporations are one of the most important R&D custodians, which carefully look for the market needs and understand their investment position as prerequisites for defining R&D projects. Castellani inspects the impact of companies' multinationalism on productivity from two viewpoints: increased productivity through the greater investment of multinational companies in R&D and the effects of large extensions on R&D activities [19]. The study captures variables such as productivity, the intensity of R&D, intensity and extent of companies' multinationalism, the intensity of capital, size, and scope of companies, as well as the ratio of capital to personnel. Research findings show that the multi-nationality of companies directly affects the intensity of R&D and upsurges productivity. Khoshnevis directed a study to scan R&D allocation resources [20]. The study surveyed leading companies that are outperforming, globally, or at the industry level. This research identifies the inefficient factors and provides suggestions for improving the efficiency of resource allocation for R&D. The criteria for review consist of internal and external R&D expenditures, R&D intensity, total personnel, number of R&D staff, purchased patents, turnover per employee (per capita), net value-added per employee (per capita), as well as financial turnover. The results indicate that companies operating in the field of R&D are dealing with two key problems: first, technical inefficiency; second, size, and

[1] Brazil, Russia, India, China, South Africa.

scope of companies. Raphael Bointner studied the extensive literature on registered patents in the energy sector, innovation drivers, existing limitations, and the knowledge gained from IEA investment in R&D and its outcomes [21]. The estimated volume of accumulated knowledge generated by the investment of the 14 IEA member countries on R&D of the energy sector in 2013 was approximately 102.3 billion euros. Linear regression analysis showed that for every billion euros of GDP, 3.1 million euros of knowledge are generated. The variables are constituted by the amount of knowledge gained from energy technologies in the years 1974 to 2013 among the 14 member countries of IEA which are lied into seven groups. The results illustrated that R&D investment by IEA members in the late 1970s equaled 0.07% of GDP, down by 0.02% in the next years, but touched 0.042% from 2011. A review on patent trends showed that countries with medium-sized classification have enjoyed from 5.9 times increase in registered patents since 1990, while large member countries experienced a rise equal to 5.6 percent.

The capital attraction strategies for R&D projects are also featured in some studies. Josef Plank analyzes the impact of state-owned R&D investment as a source of funding for R&D performance at the organization level [22]. He captures the number of patents, the number of references to patents, annual investment in R&D, return on investment, organization age, and the total capital. He concludes it is preferred for corporate managers, especially knowledge-based ones, to absorb these funds. Ibrahim A. Shaikh, states that internal managers have a positive impact on the relationship between investment and the intensity of R&D and enable the organizations to maintain a cash flow for more important R&D issues when it comes to financial distress [23]. It depends on variables such as financial investment, the severity of patents, capital intensity, organization size, and sales volume. The outcome of R&D investment can be crystallized in several ways. One of these outputs is registered patents with respect to the costs occurred. Bolívar-Ramos studied the companies' willingness to register patents and their relationship with R&D costs and network collaboration [24]. Investigation of variables such as the level of technology, previous patent experience, organization age, and size, export volume, R&D costs as well as a national, international and local network of cooperatives, revealed organizations that participate in local and national networks along with spending on R&D activities, are more likely to file a patent. Jin Chen dissects the effects of sponsoring R&D activities on the performance of the intellectual property system in IT-based companies operating in China [25]. He examined the intensity of R&D and the profit and sales of companies against the amount of financial support and concluded that financial support for R&D will have a repercussion on the performance of the intellectual property system in Chinese entrepreneur firms. Furthermore, the supportive effect of government-owned companies is weaker than private equity firms. Yu-An Huang, while analyzing R&D funding strategies, argues that capturing the predetermined outcomes from R&D investment and funding is critical, but it still leaves organizations with enticing programs [26]. Review of previous studies addressed how R&D resources provisions can influence organizations. He explicitly examines two contexts. The first area implies that different R&D funding strategies (along with a combination of different sourcing programs and product innovation) are influenced by organizational characteristics (such as supplementary technologies, technology categories, and technological competencies). The second area of interest considers the impact of these strategies on organizational procedures in terms of R&D costs and the profits of new product development. This review is based on variables such as supplementary technology, technology categories, technological competencies, development costs, financial benefits, organization size, and age, as well as the history of R&D outsourcing.

One of the most important R&D strategies can be found in the implementation strategies. In-house implementation of R&D projects, collaborating or outsourcing is a solution that has been addressed in various sources. Luigi Aldieri surveys the success of organizations in exploiting the in-house R&D outflow or purchases it from external companies and their relationship with the absorption capacity of organizations [27]. He measures variables such as net sales, the number of personnel, physical capital, R&D investment, overflow of knowledge, and the external overflow purchased into accounts and reveals that organizations with the same absorption capacity operating in a more advanced economic environment are more prosperous in exploiting R&D overflows. Morris Lampert examines the outsourcing of R&D and its role in promoting the R&D performance and organizational growth through counting the external R&D, the intensity of R&D, and the size of the organization [28]. The findings are summarized in two points. First, what increases the knowledge of organizations is not just what they can do (competencies), but also what they need to avoid (costs). Second, outsourcing the R&D (into advanced countries) promotes the level of R&D activities. Alvaro Cuervo argued two different statements about the effect of knowledge control (limit) or variety (range) of knowledge on new product development [29]. It also inspected the impact of internal and external resources on R&D. The results indicated that the control of the scope of the knowledge flow in particular cases has a greater impact on the sale of new products. The new product sales, amount of investment in outsourcing and in-housing R&D, size of the company, the foreign-owned stocks, and the number of patents are among the premeditated variables. Philip J. Steinberg explored the extent of outsourcing R&D and the impact of domestic and foreign outsourcing on innovation performance [30]. By examining indicators of R&D intensity, size, and age of the organization, the number of local R&D personnel, and the R&D outsourcing contracts, he deduced that external and internal outsourcing will have different effects on innovation performance and the number of underlying contracts is effective on the assignment and outcomes achieved. Matti Pihlajamaa studies the possibility of the appropriate use of supplier innovations as an alternative to R&D activities [31]. He investigates the absorption capacity, assimilation, and changeability's variables and concludes that replacement policies based on completing common capabilities with suppliers will be effective in the light of technological capabilities. Zhang argued that encouraging collaboration in internal R&D is an effective management strategy for innovation improvement [32]. The results of this strategy included extensive collaboration among the organization's personnel in various fields of R&D, and the acquisition of collective knowledge to facilitate innovation of the organization. To capture these results, research on the patent data of 39 companies in various fields, such as communications, information technology, automotive, pharmaceuticals, etc., was underpaid for 13 years. The empirical findings revealed the development of cooperation has a positive effect on the performance of innovation. The incongruence of technological levels among personnel also causes a kind of coordination in the innovation. The research minded the number of patents registered by companies in a given year, the type of patent registered based on the existing category, the expansion of personnel cooperation, the level of technological incongruence, R&D costs, size, and scope of organizations as well as corporate ages as key variables. Rene Belderbos indicates that organizations are generally engaged in R&D collaborations in several ways, including supply chain or customers, as well as collaborating with competitors [33]. The number of new cooperation with suppliers, competitors, and customers, innovation performance, number of disconnected partners with competitors, suppliers and customers, the intensity of R&D, size of the organization, export severity, and patents are among key variables of the study. The results suggest that successful past experiences of organizations encouraged broad cooperation in R&D activities. Areti Gkypali sets a surveying study on the R&D collaborations and the impact of collaborative diversity on innovation performance [34]. Variables of internal innovation efforts, absorption capacity, diversity of R&D cooperation, innovation performance, profitability, and profit margin were taken into accounts. The empirical results could be summarized as follows: (a) internal efforts have a positive impact on the diversification of R&D cooperation (b) the organization's efforts to innovate internally have a positive impact on innovation performance (c) generally speaking, diversifying R&D cooperation negatively affects the innovation performance.

Naghizadeh investigates and prioritizes risks of technology collaboration projects in the field of biotech. The study examines 46 technological collaboration risks lied in individual, interpersonal, organizational, and environmental dimensions. Furthermore, outsourcing-related risks that also affect R&D outsourcing projects include the inadequate commitment of senior managers, structural mismatch of counterparts, and lack of awareness of project risks. One of the factors that play an important role in formulating R&D strategy is to address areas reinforcing security in power plant environments. The designation of R&D projects in this regard, like other specialized projects, is very important. [35]

Governmental supporting policies concerning R&D are among other factors influencing the development of R&D strategies. Hiroyuki Okamuro conducted a comparative analysis regarding Japanese R&D cooperation programs and policies using the number of commercialized projects, the number of companies, the commencement time of projects and the amount of grants as institutional variables [36]. He stated that companies participating in the Ministry of Economy, Trade, and Industry (METI) project have been more committed to R&D cooperation. The study also revealed that when commercialization is of great importance for the government, this commitment should be reflected in designing corporate strategies. Furthermore, Delu Wang, examined the impact of political communication and management trust on the intensity of R&D in China's large private equity companies [37]. He argued that managerial trust can be used as a facilitator for the positive effects of political communication on the intensity of R&D. The variables incorporated in this study are including the intensity of R&D, political communication, management trust, size and age of the organization, type of industry, profitability, and the board of director's size.

To sum up the literature review, we can summarize indicators affecting the formulation of R&D strategies as presented in Table 1:

According to the literature, R&D strategies directions can be summarized into four parts:

- Formulation of R&D strategy and effectively.
- Communicating with the technology and business strategies of the organization.
- Strategies for funding R&D projects.
- Strategies for collaboration in R&D projects.
- Strategies for exploiting the governmental supportive policies to R&D projects.

3. METHODOLOGY AND DESIGN

The research is an applied one in terms of objective, because of potential implications in the power plant equipment's' manufacturing industries. The required data have been collected using interviews and questionnaires in the related industries. Therefore, it approaches descriptive surveying. The statistical population consisting of 36 managers and decision-makers engaged in R&D activities in power plant equipment's construction, has been designated through a census, due to the limited nature. The educational frequency distribution of studied groups consists of of 6% of Ph.D., 61% of MS, and 33% of BA.

The study conceptual model was obtained by reviewing literature and expert perceptions. Structural equations and Smart PLS modeling tools were utilized to validate the theorized model. GOF index is applied as the corner indicator to check the validity of model. This index examines the overall predictive power of the model and whether the fitted model has been successful in predicting endogenous latent variables. Values of 0.01, 0.25, and 0.36 are translated as strong, medium, and weak, respectively. The index values are lied between zero and one. Values close to one indicate the appropriate quality of the model. Due to the limited statistical population and ab-normality of data, PLS Smart software is implicated to perform structural equation calculations. This application software allows users to enjoy graphical markers instead of writing long and complex commands. The software is also designed to model the path of links between observed and latent variables (general model of structural equations). The method can be referred to as one of the most powerful analytical approaches because of lower dependence on measuring scales (the scale levels are not required to be interval or ratio), sample size, and residual distribution. In addition to testing theory, the method can also be applied for predictive purposes. In other words, the target is obtaining values assigned to the latent variables in order to predict and minimize the variance of all criterion variables. Furthermore, the software creates component scores for the latent variables using weights of markers. In general, a covariance-based approach is required to test the theory, as well as minimizing partial squares to discover relationships in the data and construct the theory, appropriately. The rationales behind PLS software application are summarized as low sample size and non-normality insensitivity, use of combined measurement models, the ability to use measurement models with just one question, real supporting of moderating variables, implementation of researcher-made models, as well as capabilities for

Table 1. Factors affecting the formulation of R&D strategies

Factors	Frequencies	References
Size and scope of the organization	14	Cazares [6]; Andersson [8]; Wang Ruiqi [13]; Yu-An Huang [26]; Jose Mata [15]; Peter Teirlinck [17]; Castellani [19]; Ibrahim A. Shaikh [23]; Morris Lampert [28]; Cuervo-Cazurra [29]; Philip J. Steinberg [30]; Zhang [32]; Rene Belderbos [33]; Delu Wang [37];
Sales volume	6	Andersson [8]; Ibrahim A. Shaikh [23]; Cuervo-Cazurra [29]; Jin Chen [25]; Luigi Aldieri [27]; Taewon Kang [12]
Value-added (per capita)	2	Andersson [8]; Khoshnevis [20]; Radfar [38]
Export	3	Andersson [8]; Bolívar-Ramos [24]; Rene Belderbos [33]
R&D staff	7	Andersson [8]; Jose Mata [15]; Zhang [32]; Gary Pisano [5]; Taewon Kang [12]; Laleh [10]; Khoshnevis [20]
Level of technology	3	Cazares [6]; Andersson [8]; Aldieri [27]
R&D intensity	12	Taewon Kang [12]; Peter Teirlinck [17]; Dina Pireira [9]; Castellani [19]; Morris Lampert [28]; Philip J. Steinberg [30]; Rene Belderbos [33]; Delu Wang [37]; Jin Chen [25]; Vanderpal [16]; Khoshnevis [20]; Di Cintio [18]
Number of patents	9	Dina Pireira [9]; Wang Ruiqi [13]; Khoshnevis [20]; Ibrahim A. Shaikh [23]; Vanderpal [16]; Cuervo-Cazurra [29]; Zhang [32]; Rene Belderbos [33]; Josef Plank [22];
External R&D cooperatives	6	Dina Pireira [9]; Wang Ruiqi [13]; Philip J. Steinberg [30]; Rene Belderbos [33]; Areti Gkypali [34]; Luigi Aldieri [27];
R&D costs	13	Wang Ruiqi [13]; Babkin [14]; Vanderpal [16]; Raphael Bointner [21]; Jose Mata [15]; Peter Teirlinck [17]; Rene Belderbos [33];Morris Lampert [28]; Cuervo-Cazurra [29]; Zhang [32]; Josef Plank [22]; Luigi Aldieri [27]; Khoshnevis [20]; Hiroyuki Okamuro [36]
Shareholder combination	3	Wang Ruiqi [13]; Castellani [19]; Cuervo-Cazurra [29]; Radfar [39]
Organizational capital	9	Wang Ruiqi [13]; Castellani [19]; Ibrahim A. Shaikh [23]; Josef Plank [22]; Babkin [14]; Vanderpal [16]; Luigi Aldieri [27]; Peter Teirlinck [17]; Khoshnevis [20]
Operation costs	2	Wang Ruiqi [13]; Yu-An Huang [26];
Incomes (earnings)	6	Yu-An Huang [26]; Delu Wang [37]; Jin Chen [25]; Areti Gkypali [34]; Babkin [14]; Vanderpal [16]
Organization age	6	Yu-An Huang [26]; Peter Teirlinck [17];Laleh [10]; Philip J. Steinberg [30]; Zhang [32]; Josef Plank [22]
Growth rate	1	Di Cintio [18]; Hoseinzadeh, S [40]
Employment	1	Di Cintio [18]
Productivity	1	Castellani [19]
Total number of personnel	2	Khoshnevis [20]; Luigi Aldieri [27]
National, international and local cooperation networks	1	Bolívar-Ramos [24]; Neeraj Kumar [41]; Fei Hu [42]
Supplementary technology	1	Yu-An Huang [26]
Technology classification	1	Yu-An Huang [26]; Kariman, H [43]
Technological competencies	1	Yu-An Huang [26]
Absorption capacity	2	Matti Pihlajamaa [31]; Areti Gkypali [34]
Ability to change (flexibility)	1	Matti Pihlajamaa [31]
Innovation performance	2	Rene Belderbos [33]; Areti Gkypali [34]
Number of commercialized projects	1	Hiroyuki Okamuro [36]
R&D portfolio projects	3	Hiroyuki Okamuro [36]; Matti Pihlajamaa [31]; Larsson, A. [7]
Type of industry	1	Wang Ruiqi [13]; Kariman, H [44]
Links between technological strategy and business	2	Larsson, A. [7]; Mansoori & Yavari [11]
Links between innovation strategy and business	2	Larsson, A. [7]; Mansoori & Yavari [11]
R&D process	1	Larsson, A. [7]; Xiwei Xu [45]
Laws and regulations	1	Laleh [10]; Hoseinzadeh, S [46]
Organizational structure	1	Matti Pihlajamaa [31]
Management commitment	1	Matti Pihlajamaa [31]

adopting very complex models. Fig. 1. Arranges the model referring to the literature and the indicators extracted from Table 1.

The main objective of the study is to identify and categorize driving factors and indicators according to the experts of the industry. To do this, we characterize six factors influencing

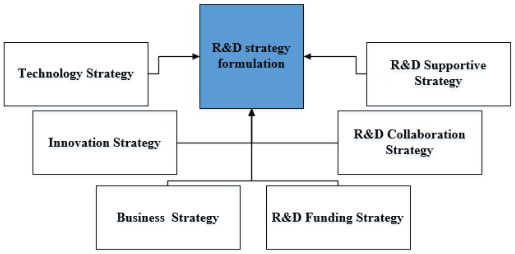

Fig. 1. Research model.

the development of R&D strategy. Introductions are briefly summarized as follows:

- R&D supportive strategy: a set of strategies and solutions that help the organization to attract R&D-related government and public support policies.
- R&D collaboration strategy: a set of guidelines and alternatives for joint implementation of R&D projects with external sources.
- R&D funding strategy: describes methods and comportments to attract a variety of investments to R&D projects.
- Business strategy: a comprehensive set of strategies and roadmaps must be taken to realize the business objectives of the organization.
- Innovation strategy: a collection of rules and solutions for the incorporation and improvement of innovation in the organization.
- Technology strategy: a set of guidelines for the development of organization technologies aligned with the business plan and strategic objectives.

4. EMPIRICAL ANALYSIS AND FINDINGS

Table 2 distinguishes 43 key factors may well affect R&D strategy model, throughout review of the literature and semi-structured interviews with industry experts. Regarding the listed factors, a questionnaire was made and distributed among statistical target samples. The validity of questionnaires has been confirmed by experts' judgment. Results were analyzed using SMART PLS software. The structural equation model analysis revealed 12 indicators having outer loading[1] of less than 0.7. Therefore, due to the divergent validity of the model, as well as to improve the reliability (Cronbach's alpha[2]), we had to remove underlying questions [47].

After eliminating 12 questions having factor loading below 0.7, the final model was again tested by PLS software for standardized and unstandardized coefficients as shown in Figs. 2 and 3, respectively.

[1]Outer loadings: are the estimated relationships in reflective measurement models [51].

[2]Cronbach's alpha is a measure of internal consistency, that is, how closely related a set of items are as a group. It is considered to be a measure of scale reliability. A "high" value for alpha does not imply that the measure is unidimensional [53].

A. Robustness Check of Reflective Measurement Model

Regarding the reliability, convergent validity, and quality of the specified model (Table 3), the robustness checks are presented subsequently.

Table 3 presents the results of various tests to confirm the validity and reliability (fitness) of factors for the structural equations model. In the first column, Cronbach alpha is calculated, all of which are above 0.7 and indicates confirmation of factors. The second column shows communality reliability, which is confirmed at the level above 0.5. The third column shows composite reliability, which is confirmed at a level above 0.7. Also, the fifth column shows the approved level of expected average variance which is above 0.5. Finally, to confirm convergent validity, the obtained composite reliability numbers must be greater than the expected average variance. Values shown in the table confirm the validity and reliability of factors.

B. Structural Model Analysis

Estimating the validity and reliability of the model make it possible to evaluate the structural model.

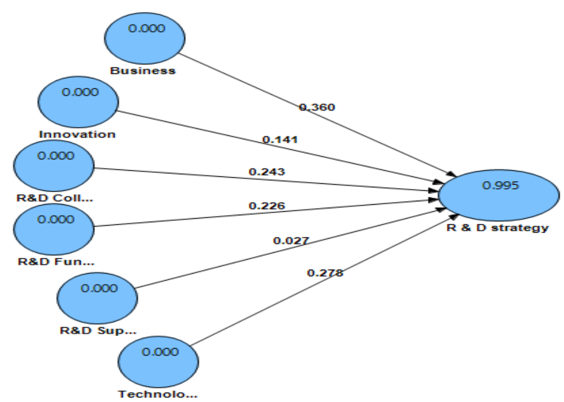

Fig. 4. Structural model in case of path coefficients estimation.

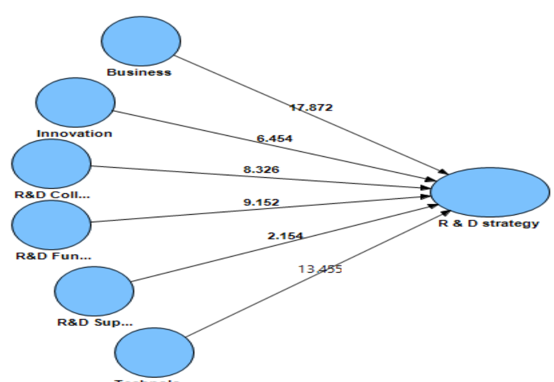

Fig. 5. Structural model in case of path coefficients significance.

Subsequent to the structural model drawing, it is required to

Table 2. Factors and indicators affecting the formulation of R&D Strategy in power plant equipment's manufacturing industries

Factors	Indicators codes	Indicators description	Outer loading	R-Squared [1]
Business strategy	bus1	Size and scope of the organization	0.171	insignificant
	bus2	Sales volume	0.82	0.6724
	bus3	Value-added (per capita)	0.769	0.5914
	bus4	Organizational capital	0.285	insignificant
	bus5	Operation costs	0.046	insignificant
	bus6	Organization age	0.738	0.5446
	bus7	Growth rate	0.069	insignificant
	bus8	Productivity	0.312	insignificant
	bus9	Total number of personnel	0.461	insignificant
	bus9.1	Organizational structure	0.788	0.6209
	bus9.2	Management commitment	0.805	0.648
R&D supportive strategy	sup1	Export	0.861	0.7413
	sup2	Employment	0.754	0.5685
	sup3	Laws and regulations	0.706	0.4984
R&D funding strategy	fun1	Number of patents	0.893	0.7974
	fun2	R&D costs	0.763	0.5822
	fun3	Number of commercialized projects	0.755	0.57
Technology strategy	tec1	Level of technology	0.927	0.8593
	tec2	Supplementary technology	0.773	0.5975
	tec3	Technology classification	0.405	insignificant
	tec4	Technological competencies	0.922	0.8501
	tec5	Links between technological strategy and business	0.76	0.5776
Innovation strategy	inn1	Absorption capacity	0.875	0.7656
	inn2	Ability to change (flexibility)	0.918	0.8427
	inn3	Innovation performance	0.528	insignificant
	inn4	Links between innovation strategy and business	0.88	0.7744
R&D collaboration strategy	col1	R&D staff	0.7	0.49
	col2	R&D intensity	0.869	0.7552
	col3	External R&D cooperatives	0.589	insignificant
	col4	Shareholder combination	0.213	insignificant
	col5	Incomes (earnings)	0.21	insignificant
	col6	National, international and local cooperation networks	0.772	0.596
	col7	R&D portfolio projects	0.579	insignificant
	col8	Type of industry	0.777	0.6037
	col9	R&D process	0.81	0.6561

[1] R-squared (R2) is a statistical measure that represents the proportion of the variance for a dependent variable that's explained by an independent variable or variables in a regression model [52].

Table 3. Validity assessment of variables

Latent variables	Convergent validity		Reliability		
	Average variance extracted [1]	CR>AVE	Cronbach's alpha	Communality reliability [2]	Composite reliability [3]
Business strategy	0.630229	OK	0.854121	0.630229	0.894872
Innovation strategy	0.852548	OK	0.913635	0.852548	0.945491
R&D collaboration strategy	0.66165	OK	0.872191	0.66165	0.906673
R&D funding strategy	0.649519	OK	0.725962	0.649519	0.846779
R&D supportive strategy	0.604046	OK	0.703358	0.604045	0.819676
Technology strategy	0.728981	OK	0.873087	0.728981	0.914231

[1] Is a measure of the amount of variance that is captured by a construct with respect to the amount of variance raised from measurement error [49].

[2] Same as average variance extracted(AVE).

[3] CR is a measure of internal consistency in scale items, much like Cronbach's alpha [49].

conduct analysis tests of this model as follows:

- Z-significance coefficients (t-values):

In the significance mechanism, the existence or lack of relationship between independent and dependent variables is scrutinized. In cases of relationship with higher than the absolute value of 1.96, it is concluded that there is a significant

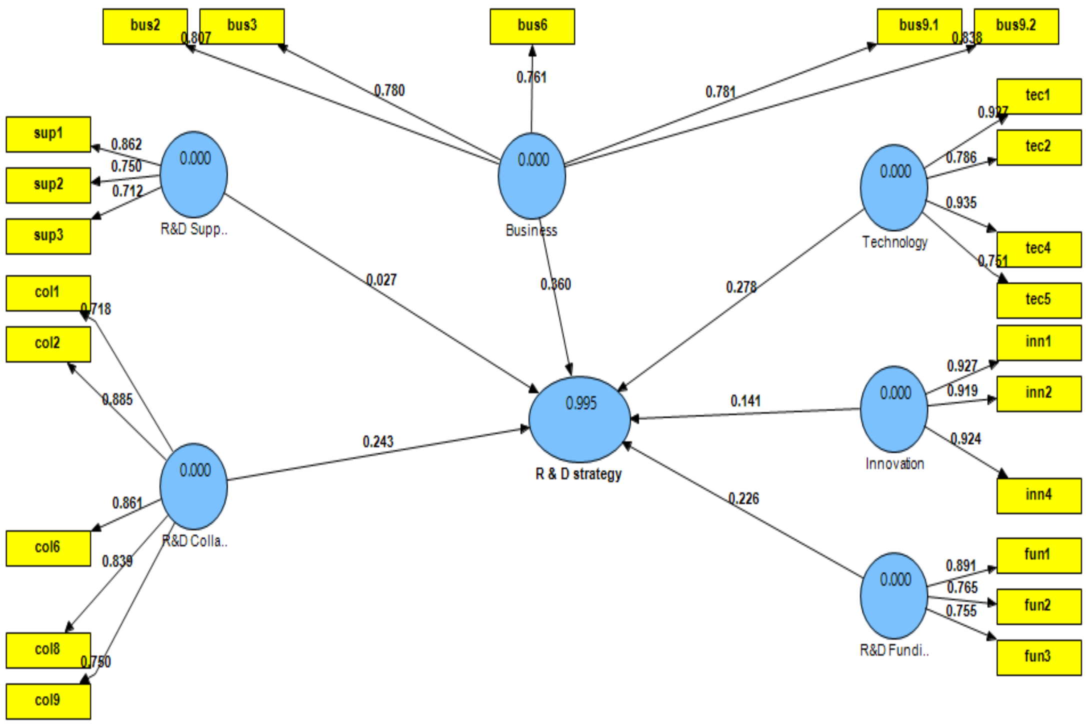

Fig. 2. Modified measurement model (confirmed) in the case of estimating standardized coefficients (factor loading).

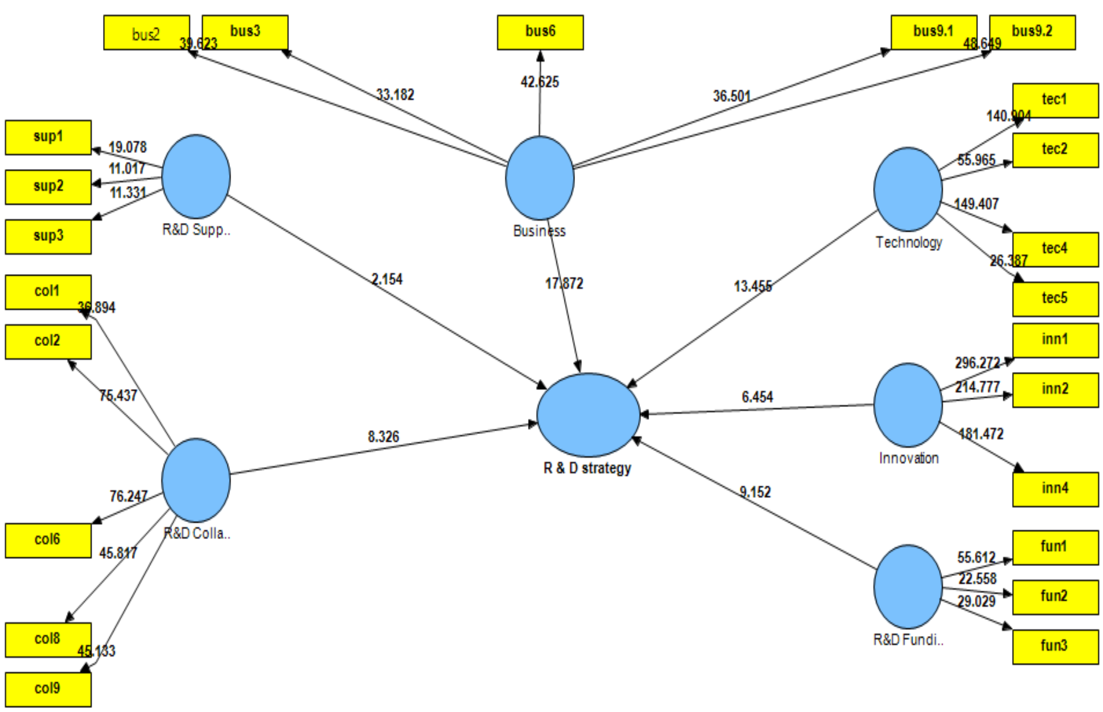

Fig. 3. Modified measurement model (confirmed) in the case of estimating unstandardized coefficients (Z-test).

relationship between the two variables with the 95% confidence level. If it takes values higher than 2.58 implies a 99% confidence level [48]. Table 4 provides the significance of the relationships between variables.

As can be interpreted, all relationships except for "R&D Supportive strategy" are significant at a 95% confidence level.

- R-Squared (R2):

Table 4. Z-significance coefficients (t-values)

Latent variables	R & D strategy
Business strategy	17.871675
Innovation strategy	6.453725
R&D collaboration strategy	8.325642
R&D funding strategy	9.151502
R&D supportive strategy	2.154354
Technology strategy	13.455174

R-squared (well-known as the coefficient of determination) is the foremost criterion for evaluating the intrinsic variables of the structural model. Value of the coefficient always lies between zero and one. R-Squared coefficients taking 0.67, 0.33, and 0.19 values in the PLS route models are counted to be significant, moderate, and weak, respectively. [49] The R-squared coefficient of the studied model equals 0.995, which is very favorable (significant).

- Goodness of Prediction (Q-Squared):

This criterion specifies the prediction power of the model. If the Q2 for an intrinsic structure value for 0.02, 0.15, and 0.35, then it signposts the weak, moderate, and strong prediction power of associated structures. The observed value of Q2 for the study is 0.2712, which designates a partially perfect prediction. [50]

- Goodness of Fit (GOF)

The GOF criterion is used to assess the quality of the structural model. Indeed, the index examines the ability to predict a model in its entirety and whether the fitted model is fruitful to estimate indigenous latent variables or not. The values of 0.01, 0.25, and 0.36 are interpreted as strong, moderate, and weak ability, correspondingly. The index values lie between zero and one and closer to one implies the more quality of the model [48] Given the GOF value of 0.825, the quality of the model seems high, entirely.

Regarding the conducted analysis, Table 5 provides the ranking of factors affecting the formulation of the R&D strategy in the power plant equipment's manufacturing industries in terms of the corresponding coefficient of determination.

Table 5. Factors affecting R&D Strategy in power plants equipment's manufacturing industries

Rank of factors	R-squared
Business strategy	0.1296
Technology strategy	0.07728
R&D collaboration strategy	0.05904
R&D funding strategy	0.05107
Innovation strategy	0.01988
R&D supportive strategy	0.0073

C. Discussions and Analysis

Reviewing and comparing the results with the literature review indicates the accuracy of the estimates. Selected indicators in the business strategy factor are referred to as empowerment indicators of the R&D strategy and related to organizational goals in the literature. Larsson studies the R&D strategy and how it supports the organization's strategies [7]. In this view, indicators such as sales volume and value-added (per capita) have a direct bearing on formulating the R&D strategy and its connections with business strategies. Also, indicators such as origination age and structure are appreciated by Teirlinck, P. and Plank, J., through a measure of organization maturity [17], [20].

R&D intensity has been respected as a key factor in the formulation of R&D strategy in almost all investigations. Rene Belderbos illustrated a variety of R&D collaboration strategies. In his category, this type of collaboration could snuggle suppliers, customers, and competitors. To conclude a collaboration, one of the core decision-making criteria is R&D intensity [33]. On the other side, absorption capacity and changeability are indicators that Pihlajamaa, M., and Gkypali, A., referred to as factors influencing the link between innovation and R&D strategies [31], [34].

Taewon Kang and Zhang have focused on the importance of R&D personnel. The findings emphasized the status of R&D personnel as one of the factors influencing the survival or exodus of R&D results in organizations [12], [32]. Ibrahim A. Shaikh and Plank in two separate studies argued that the R&D personnel and intensity significantly affect output of the R&D process and the number of registered patents resulted from R&D projects [23], [22].

5. CONCLUSION AND REMARKS

Through deep study of literature, experts' opinions, and analyzing the results using structural equations modeling and PLS software, the finalized model was developed for R&D strategy formulation in the power plant equipment's' manufacturing industries as shown in Fig. 6.

Regarding the coefficients of determination (R2) indicating the contribution of each indicator to explain the behavior of relevant factor, the following suggestions are remarked in the formulation of R&D strategy of power plant equipment's manufacturing sector.

In case of business strategy factor, the largest impact is dedicated to the sales volume index. One of the key elements to define R&D portfolio projects is the sales volume and revenue generation of the organization, which directly affects the figure and quality of such projects. Generally, the organization's ability to invest in R&D is of great importance to formulate a strategy. Therefore, companies operating in the field of power plant equipment's construction should contrive appropriate budgets for R&D. In the R&D supportive strategy context, the export index takes the most significant impact. Governments are always seeking to maintain a competitive position globally, and the export index of organizations can serve as a stimulus to exploit government supportive policies and spend on R&D. In the context of the R&D funding strategy, the largest impact

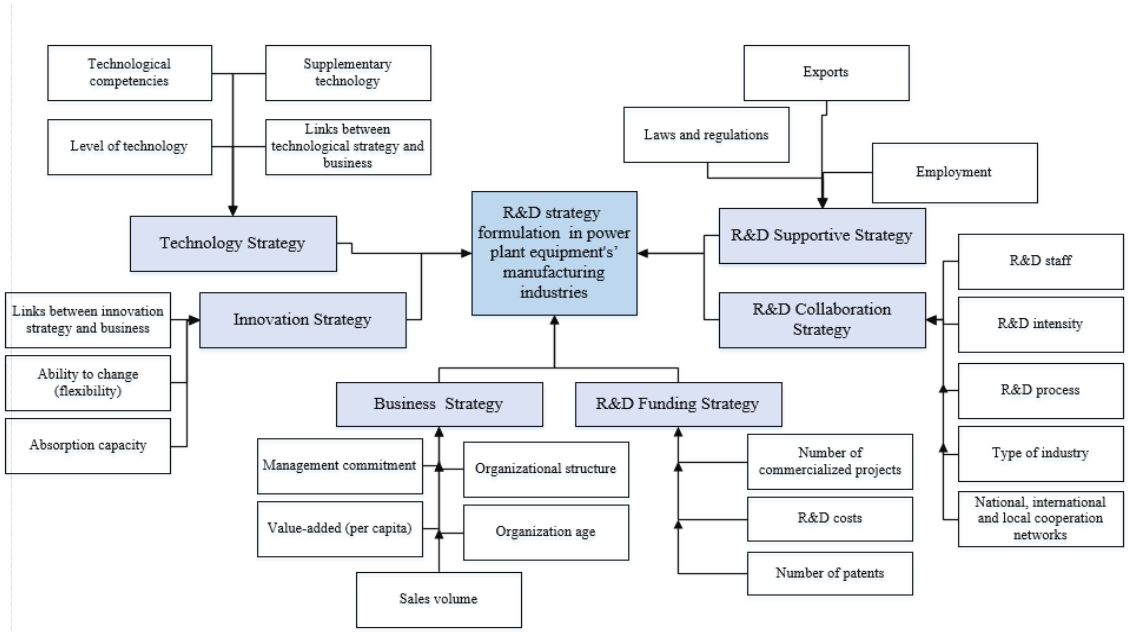

Fig. 6. R&D strategy model after the concluding analysis.

belongs to the number of patents. The number of registered patents in specified periods is considered as a satisfying output of R&D activities and influences the R&D investment decisions. Therefore, it is imperative for companies operating in the industry to file patents, carefully. For technology strategy, the competency is accounted for the most significant Index. Accordingly, it can be recommended to the companies operating in the power plant industries to identify technological proficiencies and capabilities as an instrument for R&D project prioritization. The most contributions of innovative and collaborative strategies are devoted to changeability and R&D intensity indicators, respectively. Therefore, creating processes for managing change in underlying firms and synchronizing with the output of innovations derived from the R&D process should be respected as the main priorities of this industry. Also, it is compulsive for power plant equipment's manufacturing industries to determine the inputs of R&D strategy through appropriate designation of R&D activities' level aligned with capabilities.

R&D as the engine of innovation and competitiveness in organizations and markets requires a lot of resources to achieve results. Development of R&D strategy entails identifying industry-specific priorities. Some priorities are generally implicated across different industries, but applying these priorities cannot be useful by itself. Rather, the key point of strategy formulating is minding the integrity of internal and external factors affecting such a strategy. The study, as an applied model, assistances power plant managers to comprehensively review priorities affecting R&D strategy and reduce failure costs caused by weaknesses in strategy formulation. This study takes a step forward in formulating R&D strategy in power plant equipment manufacturing industries through ascertaining effective factors on R&D strategy and correspondent factors.

One of the important points in formulating strategy in technology-oriented industries is the alignment of technology, innovation, and R&D strategies with the business strategies of organizations. Scholars can identify interconnections as well as inputs/outputs of these strategies to introduce an integrated model at the organizational level. Definition, selection, and management of the portfolio of R&D projects and the solution for their implementation (internal implementation or using the capacity of the R&D cooperation network) are of great worth in R&D field. Development of a mathematical model clarifying the pros and cons of each choice for decision-makers is also recommended for further investigation.

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