Analytical Hierarchy Process-Based Study on Key Factors of Asymmetry between R&D Investment and Performance

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ABSTRACT

Asymmetry between research and development (R&D) investments and resulting performance can be found in Taiwan, among other countries. That is, investments in R&D and innovation do not necessarily entail equivalent performance or increased competitiveness, as indicated by previous research. Nevertheless, extant research on R&D investments and performance unexceptionally concentrated on the correlation between certain R&D investment variables and economic growth, industrial value added, and business performance. The focus is simply on the verification of the correlation between R&D, innovation, and economic growth, whereas research in terms of key factors which affect the relation between R&D investments and performance is still wanting. The objective of this study was to provide an insight for mitigating potential risks in the process of R&D and innovation investments so as to increase effectiveness of R&D investment. Another aim was to provide a relatively comprehensive research foundation for future studies. In this study, 4 major dimensions and 16 key factors of the national innovation paradox were identified first based on the statistics from various databases and the enlightenment of the literature reviews. Next, questionnaires were distributed to experts and high-level senior managers of government bodies, industries, higher education institutions, and research institutions. Then, the responses from the experts to the questionnaires were undergone the analytical hierarchy process (AHP), and the weight of each factor was obtained from the result thereof. Finally, the factors were ranked according to the weights, indicating the degrees of their influence. The analysis of AHP showed that the four key factors influencing the national innovation paradox were the direction of a government's R&D policies, industries' patent development strategies, cooperation between higher education institutions and industries, and entrepreneurship incubation led by research institutions. The discovery of this study suggests substantial benefits can be generated in addressing the national innovation paradox by cementing and increasing the aforementioned four key factors. The findings will provide specific implications and references for the development of governments, industries, higher education institutions, and research institutions.

Keywords: Innovation paradox; R&D investment; R&D performance; economic growth.

1. INTRODUCTION

Do proactive R&D investments entail equivalent returns? To answer this critical yet intriguing question, this study looked into statistical data of R&D investments from the local country and abroad, such as the Organization for Economic Cooperation and Development (OECD) database, the United States Patent and Trademark Office (USPTO) patent database, and other sources. It was found that the R&D and innovation investments do not necessarily result in equivalent performance or increased competitiveness. In fact, asymmetry between R&D investments and resulting performance can be found in Taiwan and many other countries. Kokko *et al.* (2015) used the term *innovation gap* and Chan (2015) used the term *innovation paradox* to describe this phenomenon. For the purpose of exploring this topic in a more comprehensive manner, this study defined the asymmetry between R&D and innovation investments and resulting performance as a national innovation paradox and carried out an investigation in attempts to find key factors contributing to it. By "asymmetry", it means that the national investments in R&D and innovation cannot be translated into effective commercial values and cannot further enhance the economic growth and value added of the country and industry.

Domestic and foreign literature on R&D investments and resulting performance explored the correlation between R&D investment variables and economic growth, industrial value added, or business performance. Although several studies showed positive and negative correlations as well as irrelevance, they unexceptionally focused on the verification of the correlation between investments in R&D and innovation and economic growth. There was a lack of research on the key factors that affect the relation of investments in R&D and resulting performance, nor were sufficient discussions and opinions regarding this topic. On the other hand, the application of the national innovation paradox is currently a prevailing approach involving myriads of variables and possibilities, notwithstanding the complexity of selection of control variables. Therefore, the present study intended to identify the key factors of the national innovation paradox in an exploratory way to mitigate potential risks in the process of investments in R&D and innovation, increase the effectiveness of R&D investments, and provide a relatively comprehensive research foundation for future scholars to integrate and consolidate related studies.

2. REVIEW OF RELATED LITERATURE

R&D and innovation are cumulative outcomes of a series of value creations, starting with a phase of discovering an uncharted frontier in pursuit of breakthroughs in science and technology. The next is a development phase which is focused on development of key technological areas and competitive new science and technologies. This is followed by a delivery phase in which products made by using new technologies are launched in an effort to solve specific issues in the current environment. A final phase is to commercialize an innovation value, leading to value addition through innovation. However, several variables exert their impact on the process of R&D and innovation, such as the focus of a country on either basic research, applied research, or basic development, the changes in proportion of R&D investments funded by government bodies and business, the cultivation and quality of R&D workforce, the outcomes and influence of academic research, and the output value of patents and trade balance, among others. All these can act as key factors that have an impact on the transformation of R&D and innovation investments into a nation's or an industry's competitiveness.

2.1. *Comparative analyses of the R&D data of different countries*

The gross domestic product (GDP) growth rate of major economies worldwide follows the trend of global economic performance. The burst of Internet bubble in 2000 and the subprime financial crisis in 2008 had great impact on the economies of countries around the world. Nonetheless, countries were able to recover their economic growth momentum to a significant extent in the following years. Among them, two small economic entities—Singapore and Israel—are examples that are worthy of close observation. They managed to garner higher growth rates than other countries during periods of global volatility and uphold the smallest range of decline when the global economy hit rock bottom. With regard to Taiwan's economic growth rate in the past two decades, the trend curve indicates that Taiwan's growth rate was on a gradual decline. Despite the country's long-term R&D and innovation investments, the downward trend remained as the country's growth rate slowed down. In other words, the country's economic growth rate failed to pick up despite proactive investments in R&D and innovation; that is, Taiwan's investments in R&D and innovation was irrelevant to its economic growth, which depicted the issue of the national innovation paradox put forth by this study. Diving further into the value added of manufacturing industries of major economies in the past decade, the previous research observed that both China and the United States achieved a high level of value added created by the manufacturing sectors of both countries over the years and maintained substantial year-on-year growth trends. By contrast, the value added of Taiwan's manufacturing industry had been stayed at around USD 600 billion per year for the past decade, showing no significant growth or decline. This means that Taiwan's long-term R&D and innovation investments did not directly benefit the manufacturing sector's value added [Work Bank Group (2019)].

This study also analyzed the investments in basic research by different countries as one of the R&D investment categories. In proportion to the total R&D expenditures, Singapore, South Korea, and the United States, among other countries, maintained their basic research expenditures at 15%–20%; however, China, which is one of the world's second largest R&D investors, reported only 5% basic research expenditures. In 2016, the execution of basic research expenditures by enterprises was 57.7% in South Korea, 46.7% in Japan, and 5.5% and 3.2%, respectively, in Taiwan and China, which was the lowest percentage of basic research expenditures being carried out by enterprises. Over the past nine years, the proportion of basic research expenditures to total R&D expenditures has dropped year-on-year in Taiwan, accounting for only 8.7% in 2015, which was significantly lower than other major economies' R&D investment schemes, indicating that Taiwan's investments in basic research has been rapidly reduced. In terms of the proportion of various categories of R&D investments in Taiwan over the past 5 years, technological development still dominated at 67.4%–69.2%, applied research accounted for a modest share of 22.9%–23.3%, and basic research was even less, accounting for only 7.8%–9.3% of the total R&D expenditures. Because nearly 80% of the total R&D investments in Taiwan were carried out by enterprises, basic research expenditures accounted for only about 0.6%.

With regard to number of patents, the United States is the country which has the largest number of applications for patents. The number of invention patents allowed by the USPTO are widely used as an indicator for innovation. In 2017, the three largest patent applicants in the US were the United States, Japan, and South Korea. The number of patent applications of Taiwan increased from 11,071 in 2013 to 11,161 in 2017, but its overall global ranking dropped from fifth in 2007 to sixth in 2017, below the United States, Japan, South Korea, Germany, and China. China's patent applications in the US increased from 5,928 to 14,177 in 2017, reaching a high average growth rate of 24.4% through the past five years and reporting the most rapid growth rate among major patent applicants. According to the USPTO's patent database, the patent applicants of Taiwan mainly concentrated on a certain field of industries, and more than half of them were from the semiconductor and electronics industries while major universities focused on research. The organizations of top 20 patent owners accounted for 50.76% of Taiwan's total number of applications annually, among which Taiwan Semiconductor Manufacturing Company (TSMC), Hon Hai, and Industrial Technology Research Institute (ITRI) contributed 21.31% of the total. This study attributed this distribution to the major R&D and innovation momentum powered by hi-tech industries and higher education institutions.

The trade volume in patented technology is composed of technological export and import. It is a common and effective indicator for measuring a country's technological progress and can shed light on the country's degree of dependency on foreign technologies. When it is greater than 1, it suggests a trade surplus in technology; that is, the revenues from overseas sales of a country's own technologies outweigh the purchase of foreign technologies. When it is lower than 1, it suggests a trade deficit in technology; that is, revenues from the overseas sales of a country's own technologies are less than the amount spent on purchase of foreign technologies. From 2006 onward, the top three countries in terms of trade balance in technology have been Japan, Israel, and the United States, suggesting that the three have higher independent capacities in technology; further, their patents are more likely to yield economic value. By contrast, Taiwan's trade balance in technology has stayed at around 0.21 for many years, meaning that its patent technology imports were five times larger than exports. Therefore, albeit Taiwan's sixth rank in terms of patent application quantity worldwide, technological patents still needed to be purchased at a high cost from other countries, indicating that Taiwan's R&D and innovation outcomes could not be converted into actual economic value and that its independent capacity remained low.

2.2. *Review of related literatures of investments in R&D and innovation*

If studies merely focus on the relation of R&D investments with technological innovation or with economic growth, the entire picture of this research topic will be overlooked, which will then lead to biased policies. The extant literature largely analyzed the relevance and degree of influence of a single factor in the R&D investment mechanism (i.e., investments in capital or workforce) or a single factor of the output system (e.g., patents or new products) on sales and primary revenue; and the consequence of this bias was the absence of a systematic way of approaches to investigate the subject matter thoroughly and did not really reflect the correlation between R&D investments, technological innovations, and economic growth. Baneliene and Melnikas (2020) confirmed the hypothesis that R&D expenditures has a positive impact on economic growth and that the impact is much higher in well-developed EU economies under conditions of sustainable economic development and globalization. Guloglu and Tekin (2012) tested the causal relations between R&D investments, innovations, and economic growth in 13 high-income countries of the OECD and found that the relations between investments and innovations, R&D investments and economic growth, and economic growth and innovations are all positive and significant. Kiselakova *et al.* (2018) studied the member states of the EU in terms of the relation between their R&D expenditures and global competitiveness between 2007 and 2016. They found that the increase in R&D expenditures has boosted middle and eastern European countries' competitiveness. Gülmez and Yardımcıoğlu (2012) examined 21 OECD countries in terms of the long-term relation between their R&D investments and economic growth from 1990 to 2010 and found that in the long run, R&D investments showed a significant and strong correlation with economic growth. Carrillo (2019) examined the performance of the world's leading innovation countries in R&D and showed that Switzerland, the United Kingdom, and the Netherlands demonstrated the best performance in R&D investments, whereas Japan, South Korea, and Israel did not produce the same level of R&D benefits as their investments. This can be explained by the need to invest necessary management resources and costs to manage large scale R&D activities. Piekut's (2013) research results showed that three major innovation-driven European countries—Finland, Denmark, and Sweden—invested as heavily in R&D as the United States and Japan. They exhibited similarities in terms of high portions of enterprise-funded R&D investments and large numbers of patent applications, indicating a strong foothold of economic development. Similar results could be observed in Germany and Australia as well.

The innovation paradox—that is, the situation when continuous R&D investments do not yield corresponding economic growth or business performance—was not only observed in Taiwan, as shown in this study. Several other studies indicated that it existed in China as well. For example, Chan (2015) suggested that the innovation paradox existed in China, and the proof included the following: (1) despite being the world's second largest economy, China's innovation performance was overshadowed by that of South Korea, a country that is one-eighth its size; (2) China has maintained high GDP growth rates since 2008; however, its place in over half of the various international innovative competitiveness rankings has been dropping; and (3) although China became the world's largest patent applicant in 2012, the approved patents accredited to China were less than half of that of Japan. Chan also noted that the root cause for various innovation paradox phenomena in China was that the quality of China's R&D outputs was not improved at the same level as its expanded R&D investments because of rapid economic growth. Chan suggested that despite the fact that governments are the largest sponsors of innovations, their low operational efficiency has become the most prominent hurdle for innovations. Li and Jiang (2016) found the influence of R&D expenditures and the number of patent applications on economic development in China has been gradually reducing. To address this issue, the applications, transformations, and related incentives of R&D should be enhanced; meanwhile, the allocation of R&D expenditures should keep abreast of structural reforms in industries and adjust itself accordingly. One of the main reasons for the decreased influence of R&D expenditures on economic development is that for a long period of time, China has relied on new technologies imported from overseas while neglecting investments in basic research. This has led to insufficient growth momentum.

Enterprises around the world exert critical influence on proportions of national R&D investments, GDP share, and economic growth rate. Therefore, studies on industries are of great value and are included in the scope of the analysis and research of the present study. Griliches (1981) asserted that important correlations exist between R&D investments, patents, and companies' market capitalization. Sher and Yang's (2005) research supported the same result; that is, investments in R&D workforce and expenditures have a positive impact on companies' return rate of assets. They also found that organizations with higher portions of R&D personnel in their workforce are quicker to digest information, share knowledge, and re-create activities. Hong (2017) noted that in South Korea, a direct bilateral relation existed between economic growth and R&D investments in the information communication technology industry. In other words, economic growth drives R&D investments. Hong's study also indicated that compared with government-funded R&D investments, those funded by enterprises exert a more direct impact on economic growth. However, some studies on industries have also observed the phenomenon of innovation paradox. For example, Shin *et al.* (2017) found that the intensity of R&D (R&D expenses/revenue) is significantly and negatively correlated to business performance (net profits/ROA). They also found that there are excessive investments in the semiconductor industry's R&D process. Sridhar *et al.* (2013) noted that 903 high-tech companies in the US have reported no significant correlation between their R&D investments and business performance. Kaiser (2009) observed that among the Danish companies with better than average profitability, the number of patents was positively correlated with profitability, whereas companies with less than a 10% profit margin showed a negative correlation between their number of patents and profitability.

In many studies, the number of patents was used as an indicator for assessing the value of R&D and innovations. For example, Grimpe *et al.* (2017) noted that to evaluate a company's innovation performance, researchers compared R&D expenditures with the number of patents and products generated by innovations. Manual (2005) found that patents can represent the performance of innovative activities; that is, more patents indicate more R&D and innovations, and the patent is an important indicator for measuring business performance. There are different opinions and observations on the degrees of influence of R&D investments provided by governments, enterprises, and educational institutions on economic growth. Pop Silaghi *et al.* (2014) suggested that measures like tax incentives and subsidies, direct investments in education and training, patent protection, and better industrial policies could be used to promote enterprises' willingness and effectiveness in engaging in R&D investments and innovations. Szarowská (2018) put forth that donations in cash and tax cuts and exemptions were the most frequently used instruments for middle and eastern European countries to sponsor R&D activities. It was also found in the present study that government-funded R&D investments were a major driver of economic growth; however, surprisingly, R&D expenditures in higher education showed a positive yet insignificant correlation with economic growth. Min *et al.* (2020) found that commercialization efficiency is statistically higher in regions where the innovations network is larger than average. In particular, technological development efficiency is higher in regions where R&D is more public-focused than average, even though the local innovation network is small. These findings indicated that governments should consider policies that combine public investment with network building to improve efficiencies and generate technological and commercial value from regional innovations. Karadayi and Ekinci (2019) noted that factors at the national level (e.g., policies and economy) are directly correlated to the effectiveness of R&D investment. If a country has stable policies and a high-quality economic environment, R&D investments will be highly effective. Zhu and Abbas (2020) found that government grants and actor's investments can facilitate performance, but the government grant for innovations and investments has a crowding-out effect. Further, absorptive capacity positively moderates the relationship between R&D and innovation performance but plays a negative moderate role between government grant and innovation performance. Wang's (2007) cross-national study found that R&D efficiency is influenced by various governmental policies and that it is significantly and positively correlated to per capita income. In other words, if a country fails to make good use of R&D resources, it would lead to a decrease in national income or a lower rate of increase in national income. Thus, developing appropriate R&D management mechanisms would benefit R&D effectiveness. Liu and Xia (2018) found that R&D investment has generated many short-term technologically innovative outcomes and profits.

Therefore, if R&D resources are not planned and utilized in a rational manner, the result will be a massive number of technological innovations that is backward or lacking actual economic value. If R&D investments are focused only on innovative activities with low technological content in pursuit of quick economic benefits such as unoriginal R&D activities of intermediate products, changes in product appearance and image, localization and transformation of products, it would achieve nothing but short-term profits, leading only to a very low overall return on investment.

2.3. *Review of related literatures of research methodologies*

Muller and Fairlie (2001) indicated that it is difficult to apply the method of AHP if interactions within variables exist. However, a procedure has been developed whereby the correlation factors are first estimated using the method of AHP with the assumption of no interactions within variables, and then are modified to reflect any interaction effects. In the study of Ching-Pu *et al.* (2006), it was noted that the factor decomposition principle of AHP lies in striving for the independence of selection factors in each level, and if there is a dependence, the selection factors with independence and dependence can be treated separately before being combined and analyzed. The correlation factors in this study were determined first by assuming independence between selection factors, and then modifying the factors to take account of any interactions. Waris *et al.* (2019) addressed the issue of sample size by indicating that the AHP is a subjective approach for addressing specific issues. Therefore, a survey under this methodology does not require a large sample size for analyzing data. A higher degree of inconsistency is usually associated with large sample size. In addition, Cheng and Li (2002) also indicated that it may be unhelpful to use AHP in a study with a large sample size because 'cold-called' experts are likely to provide arbitrary answers, which could significantly affect the consistency of the judgments.

3. RESEARCH METHODOLOGY

This study adopted the AHP for the purpose of profiling and describing complicated decision-making and then established a straightforward hierarchy using indicators at various hierarchical levels that can be passed down to scholars and experts for pairwise comparisons. After pairwise comparisons, a positive reciprocal matrix was established, and an eigenvector of each factor of the matrix was calculated to represent a relative weight or priority of each hierarchy for reference of decision-making. Finally, a maximized eigenvalue was utilized to assess intensity of the pairwise comparison matrix's consistency. A consistence index (C.I.) and a consistence ratio were used to test the consistency of the pairwise comparison matrix.

Operational definitions of dimensions and key factors of this study are shown in Table 1.

Table 1. Definition of major dimensions

Major dimension	Operational definition
Government bodies	All agencies and organizations that provide not-for-sale public services (excluding higher education) to societies fall under this category. Such public services cannot be provided by other kinds of organizations in convenient and affordable ways. This also includes government bodies, agencies, or organizations that manage affairs of the nation and formulate economic and social policies.
Industries	Companies, organizations, and institutions whose main activity is to produce and sell products or services (excluding higher education) at profitable prices to the general public fall under this category. Private non-profit organizations mainly provide services to businesses are also included in this category.
Higher education institutions	All public and private higher education institutions and organizations, including research institutions and subsidiary organizations (e.g., entrepreneurship incubation center) affiliated therewith fall under this category.
Research institutions	Research institutions that are not owned by government bodies or enterprises, and are independent organizations operating as corporate bodies or non-profit organizations fall under this category.

Table 2. Evaluation standards

Level 1 Primary target	Level 2 Indicators of influential dimensions	Level 3 Operational definitions of key indicators
Key factors of the national innovation paradox	1. Factors of government bodies	1-1 The pertinence of R&D policies and the direction of a nation 1-2 The influence of R&D investment-related measures such as tax cuts and exemption and incentives and subsidies in funding on the overall effect of R&D 1-3 The influence of government-led public R&D investment on a nation's overall R&D effect 1-4 The influence of the magnitude of government-funded R&D investment on a nation's overall R&D effect
	2. Factors of industries	2-1 The influence of the patent development strategies of industries (i.e., whether it is defensive or offensive) on a nation's overall R&D effect 2-2 The influence of the duration of R&D investments allowed by industries on a nation's overall R&D effect

	2-3 The influence of industries' investment scale in basic research on a nation's overall R&D effect 2-4 The influence of industries' dependence on foreign patents and technologies on a nation's overall R&D effect
3. Factors of higher education institutions	3-1 The influence of higher education institutions' academic research capacity (i.e., number of papers and citations) on a nation's overall R&D effect 3-2 The influence of higher education institutions' R&D investment scale on a nation's overall R&D effect 3-3 The influence of higher education institutions' investment in cultivating R&D talents on a nation's overall R&D effect 3-4 The influence of higher education institutions' involvement in education–industry cooperation on a nation's overall R&D effect
4. Factors of research institutions	4-1 The influence of the degree of commercialization of disciplines in research institutions on a nation's R&D effect 4-2 The influence of number of patents contributed by research institutions on a nation's R&D effect 4-3 The influence of degree of technology transfer of research institutions on a nation's R&D effect 4-4 The influence of business performance of start-up companies incubated by research institutions on a nation's R&D effect

Based on the analysis of various databases and the literature reviews, this study identified 4 major dimensions and 16 key factors of the national innovation paradox, illustrated in a three-level hierarchical analysis chart according to the attributes of factors. Level 1 represented the target items, whose key factors with regard to the national innovation paradox were calculated after adding together the measurement weights of all main items. Level 2 followed the OECD's definition of R&D expenditure and execution sector classification and classified major influential dimensions into four categories—namely, government bodies, industries, higher education institutions, and research institutions—to capture the magnitude of influence of each major dimension on the national innovation paradox. The hierarchical analysis chart of this study is provided in Fig. 1.

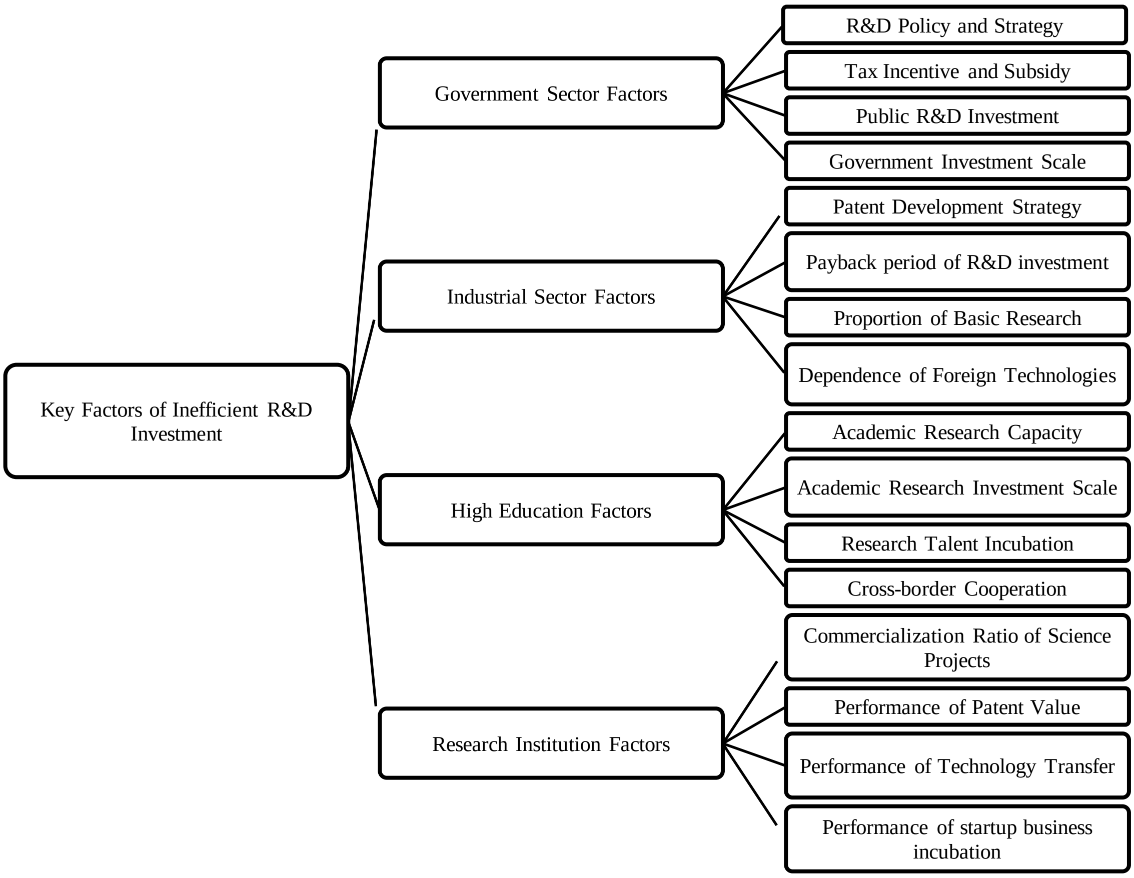

Figure. 1. Hierarchical analysis chart of this study.

For the purpose of collecting the data needed, a questionnaire survey was carried out for senior supervisors engaged in R&D matters in Taiwan. The respondents were mid- and high-level R&D supervisors (with more than 10 years of work experience) in the government bodies, industries, g higher education institutions, and research institutions; in addition, they were in charge of the R&D budget and led the implementation of R&D programs. This study distributed 49 copies of the questionnaire to experts in the related fields and recovered 35 copies from them, in which 34 copies thereof were valid with a recovery rate of 71.4%. With regard to the sectoral distribution of respondents among government bodies, industries, higher education institutions, and research institutions, Taiwanese enterprises accounted for 41%, foreign enterprises for 14%, government bodies for 21%, research institutions for 12%, and higher education institutions for 12%, respectively. In relation to the scale of respondents' organizations, 26% of organizations had 100–300 employees, 15% had 300–500 employees, 21% had 500–1000 employees, and 38% had more than 1000 employees. Regarding the work experience of supervisors, 24% had 5–10 years of experience, while 76% had over 10 years of experience. The consistency ratios of all dimensions were smaller than 0.1, suggesting that the weights indicated by the evaluation results could be regarded as reasonable. A descriptive analysis of the questionnaire samplers is provided in Table 3.

Table 3. A descriptive analysis of the questionnaire samplers.

No.	Job Title	Organization Scale	Sector	Education	Work Experience
1	Manager	1000	Research Institution	Master and above	5–10 years
2	Professor	300–500	High Education	Master and above	Over 10 years
3	Director	100–300	Taiwanese–Enterprise	Master and above	5–10 years
4	Manager	1000	Foreign Enterprise	Master and above	5–10 years
5	Manager	100–300	Taiwanese–Enterprise	Master and above	Over 10 years
6	Manager	100–300	Research Institution	Master and above	5–10 years
7	Manager	300–500	Government	Master and above	5–10 years
8	Manager	1000	Foreign Enterprise	Master and above	Over 10 years
9	Manager	500–1000	Government	Bachelor	Over 10 years
10	General Manager	100–300	Taiwanese–Enterprise	Master and above	Over 10 years
11	Manager	500–1000	Government	Master and above	Over 10 years
12	Manager	500–1000	Government	Master and above	Over 10 years
13	Manager	500–1000	Government	Master and above	Over 10 years
14	Manager	500–1000	Government	Master and above	Over 10 years
15	Manager	500–1000	Taiwanese–Enterprise	Master and above	Over 10 years
16	Director	300–500	High Education	Master and above	Over 10 years
17	Manager	1000	Foreign Enterprise	Master and above	Over 10 years
18	Manager	1000	Taiwanese–Enterprise	Master and above	Over 10 years
19	Director	1000	Foreign Enterprise	Master and above	Over 10 years
20	Manager	1000	Foreign Enterprise	Master and above	Over 10 years
21	Vice President	1000	Taiwanese–Enterprise	Master and above	Over 10 years
22	Manager	300–500	Taiwanese–Enterprise	Bachelor	Over 10 years
23	Manager	300–500	Taiwanese–Enterprise	Master and above	5–10 years
24	Professor	1000	High Education	Master and above	Over 10 years
25	Manager	100–300	Research Institution	Master and above	Over 10 years

26	Director	100–300	Taiwanese–Enterprise	Master and above	Over 10 years
27	Manager	1000	Taiwanese–Enterprise	Master and above	5–10 years
28	Director	100–300	Government	Master and above	5–10 years
29	Manager	100–300	Research Institution	Master and above	Over 10 years
30	Director	1000	Taiwanese–Enterprise	Master and above	Over 10 years
31	Chair	100–300	Taiwanese–Enterprise	Master and above	Over 10 years
32	Director	500–1000	Taiwanese–Enterprise	Master and above	Over 10 years
33	Director	1000	Taiwanese–Enterprise	Bachelor	Over 10 years
34	Professor	1000	High Education	Master and above	Over 10 years

4. DATA ANALYSIS

4.1. *Analyses of indicators for major dimensions*

This study drew up a questionnaire based on the hierarchical analysis chart developed by the researcher. In-depth interviews with experts were conducted to modify the content of the questionnaire. Subsequently, questionnaires were distributed to experts from government bodies, industries, higher education institutions, and research institutions. After the questionnaires were recovered, we used statistical software to carry out the AHP and generated the final results to calculate the weights of the influential factors of the national innovation paradox based on the questionnaires for experts. The overall weight (dominant eigenvalue of vectors) is a relative weight computed by the multiplication of major dimensions and sub-dimensions. The ranking was made according to the overall weights' sequence (as shown in Table 4).

Table 4. Analysis of the overall weight ranking of major dimensions and standards.

Dimension	Local weight	Ranking	Standard	Local weight
Factors of government bodies	0.317652	2	R&D policy direction	0.362857
			Tax incentives	0.278672
			Public R&D investments	0.168714
			Government investment scale	0.189757
Factors of industries	0.349589	1	Patent development strategies	0.325227
			Duration of R&D investments	0.194146
			Proportion of basic research	0.266308
			Dependence on foreign technologies	0.214319
	0.160891	4	Academic research capacity	0.207355

Factors of higher education institutions			Magnitude of academic research investments	0.197885
			R&D talent cultivation	0.28891
			Education–industry cooperation	0.30585
Factors of research institutions	0.171867	3	Commercialized proportion of disciplines	0.230482
			Patent output performance	0.160524
			Effects of technology transfer	0.276429
			Incubated start-up companies' performance	0.332564

For the purpose of exploring influential factors' weights of the major dimensions, this study classified the major dimensions into four categories—namely, *factors of government bodies*, *factors of industries*, *factors of higher education institutions*, and *factors of research institutions*. This study also accounted for expert questionnaires and further calculated the ranking of the individual weights of each of the four dimensions. The pairwise comparison matrix and C.I. testing for each dimension is shown in Table 5.

Table 5. Pairwise comparison matrix and C.I. testing of the major dimensions.

Key factors of the national innovation paradox	Factors of government	Factors of industries	Factors of higher education institutions	Factors of research institutions
Factors of government bodies	1	1.041501	1.854528	1.762864
Factors of industries	0.960152	1	2.508074	2.027537
Factors of higher education institutions	0.539221	0.398712	1	0.984401
Factors of research institutions	0.567259	0.493209	1.015846	1

This study referred to OECD's definition of the four major sectors that fund R&D investments (i.e., government bodies, industries, higher education institutions, and research institutions) and used them as the major dimensions in Level 2 for the AHP. The analysis of the questionnaire responses showed that the weight of industries was the highest, followed by that of government bodies, research institutions, and finally higher education institutions. Industries exert the greatest influence on the national innovation paradox; which conforms completely to the statistical result of OECD, revealing that over 70% of a nation's total R&D investment is contributed by industries. Thus, industries are the powerhouse of the national economy and the primary contributor to R&D activities. In other words, when the R&D investments of industries fails to yield value and benefits as expected, it will no doubt directly influence the performance of the nation's total R&D investment—a phenomenon described as the national innovation paradox in this study.

However, in this study, it was found that the variance between the government bodies' and industries' weight is merely 0.03; thus, with respect to influence, government bodies is equally important as industries. In other words, the respondent experts believed that the degree of influence exerted by government bodies on the national innovation paradox was as large as that done by industries. Although government bodies contributed only 20%–25% of a nation's total R&D investment, the review of literature revealed several scholars in support of the argument that government bodies exert an absolute impact on a nation's overall R&D investment and performance. For example, the United States is the country with the heaviest R&D investment and whose government-funded R&D investment has been maintained at a level above 25% of the nation's total, indicating that the US government strongly endorses R&D investment; factors such as government-led R&D policies, mode of resources input, and implementation of the incentive and subsidy mechanism have different degrees of impacts on the whole nation's R&D performance.

By contrast, respondent experts suggested that the degree of impacts exerted by research institutions and higher education institutions on the national innovation paradox was relatively limited. After all, both research and higher education institutions are auxiliary organizations that do not significantly or directly influence R&D capacities and effects. However, this does not mean that research institutions and higher education institutions are not important to the value of R&D and innovations. Instead, they are significant in terms of assisting cross-sector communications and entrepreneurship incubation. Kokko *et al.* (2015) noted that to narrow the innovation gap with the United States, countries need to continuously improve the national innovation mechanism, particularly the facilitation of cross-sector R&D cooperation between government bodies, industries, higher education institutions, and research institutions.

4.2. *Analyses of the weights and ranking of influential factors of the dimension of government bodies*

Four influential factors (i.e., sub-dimensions) of *factors of government bodies* were found in this study, namely *R&D policy direction*, *tax incentives*, *public R&D investments*, and *government investment scale*. The pairwise comparison matrix, C.I. testing, and weight ranking of *factors of government bodies* are shown in Tables 6 and 7.

Table 6. Pairwise comparison matrix and C.I. testing of the factors of government bodies.

Factors of government bodies	R&D policy direction	Tax incentives	Public R&D investments	Government investment scale
R&D policy direction	1	1.25875	2.136176	2.035993
Tax incentives	0.794439	1	1.681754	1.404834
Public R&D investments	0.468126	0.594617	1	0.882536
Government investment scale	0.491161	0.711828	1.133098	1

Table 7. Weight ranking of factors of government bodies.

Factors of government bodies	Normalized real number	Weight ranking
R&D policy direction	0.36285697	1
Tax incentives	0.278671722	2
Public R&D investments	0.168714499	4
Government investment scale	0.18975681	3

The results indicated that among the sub-dimensions, the weight of *R&D policy direction* was the largest, followed by that of *tax incentives*, *government investment scale*, and *public R&D investment*, as shown in Table 6. The nation-led R&D policies exert absolute influence on the national innovation paradox, which is supported by many scholars, as provided in the literature review. A solid national R&D policy can underpin the cultivation of high value-added industries and drive the whole country's R&D growth momentum, thus further elevate the country's overall economic growth. By contrast, if a country chooses an incorrect R&D policy direction or fails to implement the policy with actual actions and measures, it will curb the country's overall R&D investment from reaching the expected outcome. Referring to the example of Taiwan's industrial policies over the past decade, the government has proactively rolled out the Two Trillion & Twin Star Project and focused on supporting the semiconductor, display technique, digital content, and bio-tech industries. However, because of issues arising from the implementation of projects and the conflict of policies, outstanding R&D outcomes and economic performances were not achieved in these industries despite the massive amount of national resource input. The results of the present study verified Chan's (2015) observations: despite the fact that governments are the largest sponsors of innovations, their low operational efficiency have become the most prominent hurdle for innovations. The root cause for various phenomena related to the innovation paradox is that the quality of China's R&D output has not improved to the same extent as its expanded R&D investments as a result of rapid economic growth. Karadayi and Ekinci (2019) also noted that environmental factors at the national level (e.g., policies and economy) are directly correlated to the effectiveness of R&D investment. If a country has stable policies and a high-quality economic environment, great effectiveness would be generated for R&D investments. Wang's (2007) cross-national study suggested that if a country fails to make use of its R&D resources, it would lead to a decrease in the national income or a smaller increasing rate of the national income; thus, developing appropriate R&D management mechanisms would effectively benefit R&D effectiveness.

In some middle European and developing countries, governments' tax incentives are key factors in improving R&D and innovation outcomes. The tax incentives and subsidies delivered by these governments can promote industries' R&D investment. However, such incentives cannot meet the demand of the whole society in the long run, which means that every enterprise that is willing to invest in R&D may not be able to have the necessary resources allocated to them. Moreover, the prevalence of red-tapism in the process of applying for government subsidies limits the capabilities of small enterprises that do not have the capacity to cooperate with such long, complicated resource application processes. Therefore, in the long run, incentives and subsidies will be seized by enterprises that are large in size and familiar with the mechanisms, which will result in an unbalanced allocation of resources. This is one of the root causes why government investment fails to achieve expected effects.

Respondent experts suggested that the government investment scale and public R&D investment were not key factors that influence the national innovation paradox. This opinion is consistent with the OECD's statistical data regarding R&D investment of countries; that is, in the world's major economies, government-funded R&D investment accounts for 20%–30% of each nation's total R&D investments. Therefore, the scale of government-funded R&D investments—whether large or small—did become an absolute influential factor for the national innovation paradox. Moreover, most of the government-led public R&D projects are infrastructure constructions, which are also assistive in nature. Thus, their influence is far less than a country's R&D policy. Nevertheless, Halásková and Bednář (2018) studied public R&D and found that in countries that are relatively slack in R&D, the public R&D expenditure would bring very strong effects. In other words, in countries with weak R&D capacities, government-funded public R&D expenditure generates direct benefits.

4.3. *Analyses of the weights and ranking of influential factors of the dimension of industries*

Under factors of industries, four sub-constructs or influential factors, namely *patent development strategies, duration of R&D investments, proportion of basic research,* and *dependence on foreign technologies,* were found. The pairwise comparison matrix, C.I. testing, and weight ranking of factors of industries are shown in Tables 8 and 9.

Table 8. Pairwise comparison matrix and C.I. testing of the factors of industries.

Factors of industries	Patent development strategies	Duration of R&D investments	Proportion of basic research	Dependence on foreign technologies
Patent development strategies	1	1.913593	1.178561	1.411063
Duration of R&D investments	0.522577	1	0.791506	0.9372
Proportion of basic research	0.848492	1.263414	1	1.323068
Dependence on foreign technologies	0.708686	1.067008	0.755819	1

Table 9. Weight ranking of factors of industries.

Factors of industries	Normalized real number	Weight ranking
Patent development strategies	0.325227122	1
Duration of R&D investments	0.194146538	4

Proportion of basic research	0.266307483	2
Dependence on foreign technologies	0.214318857	3

As shown in Table 9, the analysis results of the questionnaire indicate that *patent development strategies* have the highest weight, followed by *proportion of basic research*, *dependence on foreign technologies*, and *duration of R&D investments*. This result indicated that from the angle of industries, the patent development strategies are the most influential and essential factor to the national innovation paradox, which is consistent with the discussion in the literature review of the present study. Taiwan's trade balance in technology has been at around 0.21 for many years, and its imports of patent technologies are five times larger than its exports of patents. Therefore, albeit Taiwan's sixth rank in terms of the number of patent applications worldwide, there is still a need to purchase technological patents at a massive expense from other countries, indicating that Taiwan's R&D and innovation outcomes cannot be converted to actual economic value, and its independent capacity remains low. The unbalanced patent distribution and trade deficit indicate an important innovation paradox: Taiwan's industries have invested heavily in R&D activities; however, the output of such activities is predominantly the so called *defensive patents* or auxiliary patents for improving processes; such patents can be used only for cushioning against other enterprises' aggressive activities during a patent war and cannot contribute actual economic value for industries, thus forming a typical phenomenon of the national innovation paradox. Daiko *et al.* (2017) suggested that over half of the major R&D investors used the full IP bundle (i.e., patent, trademark, and design) approach, to strengthen the commercial value of patents and that their patent strategies were adjusted in accordance with the target market and the specific industry in which the enterprise operates in an effort to enhance the value and outcomes of patents. The proportion of basic research is another challenging issue for industries to tackle in terms of R&D and innovations. Enterprises in developing countries pay attention to the R&D of pragmatic technologies in the hopes that they may be able to achieve concrete effects in the short term. As a result, they neglect the development of basic research in the long term. The results of comparative research in this study indicate that Taiwan and China have the lowest proportions of basic research exercised by enterprises with the percentage of 2016 being 5.5% and 3.2%, respectively. Furthermore, of all the enterprises-funded R&D expenditure in Taiwan, the portion spent for basic research merely accounts for around 0.6%. The side effects of this deep-seated negligence of basic research include a lack of core technology to compete with international enterprises, a difficult situation in securing a unique competitive edge in R&D and innovations worldwide, and the role of a follower in the entire industry. By contrast, several leading developed countries invest much more heavily in basic research, and these countries have indeed been the leaders of R&D and innovations in many domains. This is solid proof that the magnitude of enterprises' investment in basic research is an important and essential factor contributing to the national innovation paradox.

4.4. *Analyses of the weights and ranking of influential factors of the dimension of higher education institutions*

Under the major dimension factors of higher education institutions, four sub-constructs or influential factors, namely *academic research capacity, magnitude of academic research investments, R&D talent cultivation, and education–industry cooperation,* were found. The pairwise comparison matrix, C.I. testing, and weight ranking of factors of higher education institutions are shown in Tables 10 and 11.

Table 10. Pairwise comparison matrix and C.I. testing of the factors of higher education institutions.

Factors of higher education institutions	Academic research capacity	Magnitude of academic research investments	R&D talent cultivation	Education–industry cooperation
Academic research capacity	1	1.152436	0.70405	0.633556
Magnitude of academic research investments	0.867727	1	0.685419	0.696631
R&D talent cultivation	1.420354	1.458962	1	0.932625
Education–industry cooperation	1.578393	1.435481	1.072243	1

Table 11. Weight ranking of the factors of higher education institutions.

Factors of higher education institutions	Normalized real number	Weight ranking
Academic research capacity	0.207355329	3
Magnitude of academic research investments	0.197884663	4
R&D talent cultivation	0.28891	2
Education–industry cooperation	0.305850008	1

As shown in Table 11, the results of the analysis of questionnaires indicate that *education–industry cooperation* has the highest weight, followed by *R&D talent cultivation*, *academic research capacity*, and *magnitude of academic research investment*. This result shows that with regard to higher education institutions, education–industry cooperation is an essential influencing factor in the national innovation paradox. According to the statistics of the OECD, the majority of R&D investment in basic research usually comes from higher education institutions. In Taiwan and China, the proportions of basic research conducted by higher education institutions are 54.2% and 52.6% respectively. If higher education institutions can scale up communications and cooperation with industries through their basic research outcomes, it will further make up for the insufficient input from industries in terms of basic research. For example, in the United States, several important basic research outcomes start from university labs and are further utilized to create new business opportunities. In particular, Silicon Valley, a place with strongest R&D energy in the world, is located close to Stanford University, and for a long time, the two have collaborated closely in the R&D of new technologies. Moreover, top universities of American's Ivy League are owners of numerous key patented technologies. All these aspects prove that higher education institutions play an essential role in influencing basic research and cross-sector education–industry cooperation.

The most important mission and mandate for higher education institutions have always been the cultivation of talents. Over the past two decades, as a result of the inclusive education policies in Taiwan, every individual has the opportunity to receive higher education. However, against the backdrop of the massive cultivation of talents, industries have complained about less than expected quality of talents, as well as their insufficient expertise and severe lack of practical experience. In other words, despite the skyrocketing quantity of talents cultivated in Taiwan in the past two decades, the quality of these talents has been dropping significantly. Moreover, although the number of graduates is huge every year, several enterprises still fail to find suitable professionals. This is one of the key influential factors in the national innovation paradox that should be paid attention to.

4.5.*Analyses of the weights and ranking of influential factors of the dimension of research institutions*

Under factors of research institutions, four sub-dimensions or influential factors, namely *commercialized proportion of disciplines, patent output performance, effects of technology transfer, and incubated start-up companies' performance*, were found. The pairwise comparison matrix, C.I. testing, and weight ranking of factors of research institutions are shown in Tables 12 and 13.

Table 12. Pairwise comparison matrix and C.I. testing of the factors of research institutions.

Factors of research institutions	Commercialized proportion of disciplines	Patent output performance	Effects of technology transfer	Incubated start-up companies' performance
Commercialized proportion of disciplines	1	1.497925	0.778042	0.703724
Patent output performance	0.66759	1	0.5269	0.534818
Effects of technology transfer	1.285277	1.897892	1	0.724576

Incubated start-up companies' performance	1.421012	1.869796	1.380117	1

Table 13. Weight ranking of the factors of research institutions.

Factors of research institutions	Normalized real number	Weight ranking
Commercialized proportion of disciplines	0.230481999	3
Patent output performance	0.160523997	4
Effects of technology transfer	0.276429328	2
Incubated start-up companies' performance	0.332564675	1

As shown in Table 13, the results of the analysis of the questionnaires indicate that *incubated start-up companies' performance* has the highest weight, followed by *effects of technology transfer*, *commercialized proportion of disciplines*, and *patent output performance*. This result shows that with respect to research institutions, incubated start-up companies' performance is the most influential and essential factor to the national innovation paradox. In Taiwan, the semiconductor industry was born in the ITRI and gradually evolved into two major companies—the TSMC and the United Microelectronics Corporation—contributing to the economic boom in Taiwan over the past decades. This successful model proves that research institutions play an important role in R&D and innovations. Over the past decade, major research and higher education institutions have set up entrepreneurship/innovation incubation centers. If doing so can create unicorn enterprises that bring about an economic boom again, it would greatly benefit the entire nation's R&D and innovation investments.

The respondent experts also agreed that the effects of technology transfers were one of the key factors of the innovation paradox, and research institutions played a leading role in guiding basic R&D. However, regarding the current technologies that research institutions are working on, the public is unaware which are the ones that are relatively mature and which are the ones that can be transferred. Although industries have the intention to exchange and transfer technology with research institutions, it is unlikely for them to find a channel to do so. Therefore, the mechanism of technology transfer should be more open and transparent so as to promote cooperation between industries and research institutions.

5. CONCLUSION AND RECOMMENDATION

5.1. *Research conclusions*

The national innovation paradox is a "problematique" structure, involving many variables and possibilities, and the choice of control variables is also considerably complex as these problems are composed of numerous interactive elements including those that are tangible or intangible and qualitative or quantitative. For decision makers, a hierarchical structure analysis contributes to comprehension; however, when faced with "choosing the right solution," alternatives must be assessed against certain benchmarks to determine the advantages of the alternatives so as to identify the appropriate options. This study hopes to achieve the purpose of providing reasonable evaluation by using multi-criteria evaluation theory. After evaluating the diverse and multi-criteria evaluation methods, the AHP hierarchical analysis method—a method that can systemize and structure complex problems, which is suitable for practical research on this topic—was used herein to construct a key element system to evaluate critical factors. In addition, the concept of fuzzy proximity analysis was used to analyze the importance level of key elements of innovation paradox.

The AHP method considers complex problems according to different levels so that complex problems can be systematized and structured. It is a quantitative method that uses different levels to provide a hierarchical decomposition, finds the key factors through quantitative judgment, and then creates a comprehensive assessment to allow decision makers to choose an appropriate solution with sufficient information while reducing the risk of decision-making errors. To do so, the method decomposed a problem into a clear and elemental hierarchy with several levels through an analysis of the impact of the elements of each level on its upper-level elements. Next, the result of the analysis is calculated according to the hierarchy's structure, and weight values of the elements in the secondary level with respect to the elements in the upper-level are derived, such that the impact of the key factors of the national innovation paradox can be further studied.

The following findings are revealed in the present study. The four major key factors influencing the national innovation paradox are the direction of the government's R&D policies, the patent development strategies of industries, the cross-sector cooperation between higher education institutions and industries, and the performance of start-up companies that are incubated by research institutions. A good national R&D policy can underpin the cultivation of high value-added industries, drive the R&D growth momentum nationwide, and further bolster the nation's economic growth rate. Industries can transform their operational models of R&D and innovations and make use of the full IP bundle (patent, trademark, and design) method to strengthen the commercial value of patents so as to boost their unique competitive edge. Higher education institutions can utilize their investments in basic research and engage in exchange of research results and cooperation with industries, thus helping industries fill gaps in basic research. The role of research institutions can be powerhouses and incubators for innovations, for they can help develop core technology for unicorn startups through the entrepreneurship incubation mechanism. Substantial benefits can be generated upon addressing the national innovation paradox by cementing and increasing the aforementioned four key factors. Meanwhile, government bodies, industries, higher education institutions, and research institutions can also draw specific references from these aspects and draw up suggestions.

5.2.*Managerial implications*

The results of this study indicate that from the perspective of the government bodies, the key factors influencing the national innovation paradox are R&D policy direction and tax incentives. The government should learn lessons from advanced countries around the world in terms of its primary R&D policies and future trends. It should make good use of its own advantages and core competitive edge and extensively collect various opinions from government bodies, industries, higher education institutions, and research institutions to orchestrate a national R&D guideline suitable for the next 5–10 years. In addition, it should make efforts in promoting and guiding the development of relevant industries, ramp up exchange and cooperation between government bodies, industries, higher education institutions, and research institutions, and provide tax incentives and related subsidies through an efficient management mechanism.

With regard to industries, their patent development strategies and proportion of basic research are crucial factors that influence the national innovation paradox. Therefore, industries should modify their old method of operating patents and adopt the full IP bundle approach to increase the commercial value of patents. In other words, integrating patents, trademarks, and designs with a market value-oriented concept to make a combination with greater value. By doing so, the defensive strategy that has been used to operate patents will be transformed to a new combination mode featuring patent integration in pursuit of higher commercial value. Furthermore, industries should scale up investments in basic research to gradually develop core technologies; although the outcomes of basic research might not lead to considerable commercial performance in the short term, they will form the most essential core competitiveness of industries in the middle to long terms.

From the perspective of higher education institutions, cross-sector education–industry cooperation and the cultivation of talents are the most important factors influencing the national innovation paradox. Therefore, this study recommends that higher education institutions must learn from the leading universities in the United States and Europe in terms of R&D capacity, focus on developing basic research, and expand the cooperative magnitude between themselves and industries through a joint model featuring education–industry collaboration. On the one hand, these measures can improve universities' core competitiveness and advantages. In addition, they can provide fundamental momentum for industrial development. Furthermore, higher education institutions should change their quantity-over-quality mentality in cultivating talents and strengthen the pragmatic capabilities of each research talent in an effort to provide industries the much-needed R&D workforce.

With regard to research institutions, incubated start-up companies' performance and effects of technology transfer are the most influential factors in the national innovation paradox. Therefore, the present study recommends that research institutions must take the initiative in seeking greater cooperation with other sectors (e.g., government bodies, industries, and higher education institutions) and utilize the entrepreneurship incubation mechanism to jointly forge a new chapter in start-up cultivation. They can learn from the founding history of TSMC in terms of integrating resources from government bodies, industries, higher education institutions, research institutions, and foreign business to make concerted efforts to develop next generation core technologies and industries for the fundamental growth of the nation. Meanwhile, research institutions should adopt a more inclusive mechanism and a cooperative mode that enables government bodies, industries, and higher education institutions to learn about the list of technologies ready for exchange or transfer to create more opportunities for research institutions in applying R&D outcomes and carrying out technology transfer.

Contrary to the results of this study, current R&D policies and investments in Taiwan focus on applied research and technological development, and very rare basic research had been invested by enterprises and government bodies. The patent applications are dominated by few high-tech industries and higher education institutions, and most of the patent development is the defensive strategy that is difficult to generate business value. The mechanism of startup company incubation is immature, and the collaboration within high education, research institutions and industries still have improvement areas in each of the sectors.

Taiwan government realizes that the bottleneck and paradox of R&D and innovations are influential to the economic growth momentum, and thus the government is starting to refine the country's science and technology development policies for the next four years. The new R&D policies are divided into four main topics: “Talent and Value Creation,” “Research and Outlook,” “Economics and Innovations,” and “Safety Society and Smart Life”. “Talent and Value Creation” promotes the legislation on industrial and academic cooperation, talent incubation and innovation regulations in key areas, setups relevant research institutes, and promotes the foreign professionals’ recruitment and employment law to incubate domestic scientific and technological R&D talents. “Research and Outlook” proposes the institutionalization of basic research budget planning, deploying resources for industrial advanced technologies development, and establishing academic research centers to improve the capabilities of basic scientific R&D. “Economics and Innovations” proposes to improve the environment of start-up company incubation and enhance the capability of internationalization. “Safety Society and Smart Life” focuses on the data governance and security, advanced network infrastructure, and big data analysis capability for precision healthcare industry. These approaches for scientific and technology development policies for the next four years are fully consistent with the results and managerial implications of this study and are sufficient evidence of the substantial contribution and academic value of the results of this study.

5.3. *Research limitations*

This study is exploratory in nature, with an intention to define the key factors influencing the national innovation paradox. It attempted to pool holistic information from major countries in the literature review. As a result, some details and micro angles in making comparisons were inevitably neglected. Therefore, we recommend future studies on related subjects to conduct thorough analyses on the key factors of the national innovation paradox as defined in this study and to carry out comparative analyses between different countries. This study also recommends that researchers adopt the time-series approach and investigate changes in key factors during a specific time period. Moreover, researchers should explore and analyze key factors under the various major dimensions, that is, government bodies, industries, higher education institutions, and research institutions.

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