Economic Growth and Design Capability: A Comparative Study of Singapore, South Korea, Taiwan and Finland

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Article Info
Journal of Enterprise and Business Intelligence (https://anapub.co.ke/journals/jebi/jebi.html)
Doi: https://doi.org/10.53759/181X/JEBI202505009
Received 10 April 2024; Revised from 17 November 2024; Accepted 25 January 2025.
Available online 05 April 2025.

Abstract – This study provides a comparative analysis of the economic growth and design competences of Taiwan, Singapore, Finland, and South Korea, employing both qualitative and quantitative methods to provide an inclusive assessment of each country's performance in economic development, R&D expenditure, and technological output. We integrate economic indicators such as GDP per capita, adjusted for R&D strength, and Purchasing Power Parity (PPP), alongside the analysis of patents granted per capita. Data were sourced from reputable organizations like the IMF and OECD, ensuring reliability through data triangulation and statistical validation using correlation and regression models. The results highlight significant differences in economic trajectories and design capabilities. Singapore's growth is driven by multinational corporations and substantial government investment in infrastructure and education, yet it lags in R&D intensity. South Korea's economic success is fueled by large conglomerates (Chaebols) with substantial private sector R&D expenditure. Taiwan excels in patenting but has moderate publication output, indicating strong capacity in converting technical knowledge into commercial innovations. Finland's innovation landscape is heavily influenced by Nokia, which dominates its patent output. The study concludes that while all four countries show consistent growth in quantitative indices, distinct paths in developing design capabilities are evident, with significant differences in the role of private versus public sector investment and the impact of multinational corporations on national innovation landscapes.

Keywords – Economic Growth, Research and Development Expenditure, Purchasing Power Parity, GDP Per Capita, Commercial Innovation.

I. INTRODUCTION

Economic growth is a multilayered and long-term process that is influenced by various constraints, like excessive government intervention, population growth, inefficient resource utilization, limited resources, inadequate infrastructure, and cultural and institutional barriers that hinder progress [1]. Economic development is achieved via the optimal use of existing resources and by enhancing a country's production capability. It enables the transfer of wealth from one group of people to another, benefiting both individuals and the whole community. The compounding impacts, the marginal disparities in growth rates, become significant during periods of ten years or more. Redistributing funds is more feasible in a dynamic and expanding society than to a stagnant one. There are instances when economic growth is mistakenly associated with economic swings. Implementing expansionary monetary and fiscal policies has the capacity to eliminate recessionary gaps and boost the gross domestic product (GDP) beyond its potential level.

The emphasized the necessity for more study in identifying the conceptual connections between the operation of the financial system and economic development. There are two other aspects that are worth highlighting. Initially, our comprehension of the genesis, progression, and economic consequences of various financial systems is not enough rigorous. The financial structure, which refers to the combination of financial contracts, markets, and institutions, differs across nations and undergoes changes as countries progress in their development. However, our current understanding of the reasons for the emergence or evolution of various financial institutions is insufficient. Incorporating legal tradition disparities and variations in national resource endowments that result in diverse political and institutional frameworks should be included in future models of financial growth. In addition, economists must provide an analytical framework for comparing financial structures. We need models that clarify the circumstances, if any, in which certain financial structures are more effective in reducing information and transaction costs [2].

In [8] provide empirical data showing that investment in Research and Development (R&D) not only contributes to innovation but also facilitates the integration of research findings from various sources. The magnitude of the spillovers is contingent upon the level of one's own R&D endeavors. Based on current statistics from the European Commission, Portugal, Spain, Finland, and Ireland are the four nations in the European Union that have had the most significant growth in their R&D spending between 1995 and 2000. The average yearly increase in resources allocated to R&D activities as percentage of GDP was 10.92%, 13.02%, 6.32%, and 10.01% correspondingly. In Greece, the actual increase in R&D endeavors was 5.09%, surpassing the average of the European Union (EU) by a little margin, which stood at just over 3%. Nevertheless, the majority of the European periphery, particularly Greece, Portugal, and Spain, continue to lag behind in terms of the overall R&D expenditure. The nations allocated 0.51%, 0.78%, and 0.9% of their GDP to R&D activities, respectively. This is in contrast to the EU mean of 1.92%. Nations located on the European margin are making efforts to narrow the technological disparity, nevertheless, the disparity remains substantial [3].

This research aims to compare the economic growth trajectories and innovation capabilities of Finland, Singapore, Taiwan, and South Korea by analyzing key economic indicators like R&D strength and PPP. It seeks to determine the differences in R&D outlay across these nations and the roles of public and private sector investments. The study will investigate the technological output by analyzing the number of patents provided per capita and the effect on national innovation landscapes. Additionally, it will explore the design capabilities and innovation strategies of these countries, focusing on the conversion of technical knowledge into commercial innovations. Finally, the research will identify the key factors influencing economic development and innovations, including the objective of multinational corporations, federal policies, and the presence of large conglomerates. The main research questions include:

1. How do the economic growth trajectories of Finland, Singapore, Taiwan, and South Korea compare when analyzed using R&D intensity and PPP?
2. What are the differences in R&D expenditure between these countries, and how do public and private sector investments contribute to their innovation systems?
3. How does the technical output, gauged by the patents granted per capita, differ among Singapore, South Korea, Taiwan, and Finland?

The remaining sections of the article have been arranged as follows: Section II presents the conceptual framework that highlight theories of economic development, R&D expenditure, and relationship between economic development and R&D expenditure. Section III reviews various related works on the various topics introduced in the conceptual framework section. Section IV identifies the data and methods used to collect data, including its validity and variability. Section V discusses the findings obtained in the research to further understand concepts such as economic development, R&D expenditure, R&D output, technology-based companies, and recommendations of design perception. Section VI concludes the research by summarizing the findings.

II. CONCEPTUAL FRAMEWORK

Theories of Economic Development

The examination of the theory of economic development starts with the name Joseph Schumpeter. In contrast to traditional theories, Schumpeter did not see the accumulation of capital as the primary catalyst for economic expansion. He attributed significant significance to the notion of the entrepreneur-innovator, referring to them as a “champion of progress”. According to Gilbert, the economic progress was decided by the invention and inventiveness of entrepreneurs. Schumpeter firmly believed in the asymmetrical character of economic progress. Schumpeter's work ascribed that process to the inherent characteristic of the 'jump'. After the implementation of a novel idea, an entrepreneur initially experiences substantial profits. However, as time progresses, competitors imitate the invention, resulting in a gradual drop in revenues [4].

Chong and Calderón established a theoretical model to support Lewis's ideology identified as the “Kuznets curve”. Empirical study has shown the existence of economic disparities throughout the first stages of advancement. The differences were most noticeable at first when workers began to shift from farm to industry; however, they steadily decreased as sources of production were consolidated in industrial hubs. Kuznets found a positive relation among the rate of economic expansion and the growing share of the population living in cities. But Lewis's theory makes certain difficult to accept assumptions. Poverty is a problem that cannot be ignored forever. In the end, the increased accumulation of wealth would result from a reduction in consumption, which would disproportionately affect those who are the most economically disadvantaged.

R&D Expenditure

Economic growth generally results in increased wealth for all individuals. Hence, factors (such as R&D) expenditure that influence economic development are crucial. The outcome of R&D spending on economic development has been the focus of several studies, with diverse results. The literature on economic growth, both empirical and theoretical, highlights the implication of investments in R&D as a crucial driver of sustainable economic advancement. Furthermore, it emphasizes that increased innovation resulting from such expenditures has a favorable impact on productivity. Indeed, nations that prioritize R&D operations have been generating greater value and achieving superior economic performance. The primary inquiry pertains to the existence of positive correlations between economic development and investment in R&D. This investigation focuses on a limited sample of five nations, namely Singapore, South Korea, Taiwan, and Finland.

Additionally, it aims to determine whether the outcomes vary based on the variable degrees of growth among the countries included in the sample [5].

Relationships Between R&D Expenditure and Economic Growth

Scientific literature on R&D, and their impact on socio-economic progress, is extensive. Various variables impact economic growth, and existing literature provides evidence that R&D plays a substantial role in driving it. In their study, Gumus and Celikay examined the relation among R&D outlay and per-capita GDP in 23 developing nations from late 1990s to 2023. Tiebout found a noteworthy influence of R&D venture on economic development. According to Bogliacino et al. there is a clear link among economic development and R&D investments in Sweden.

We highlight this relationship using 4 countries: Singapore, South Korea, Taiwan, and Finland. Singapore has a GDP of $364.2 billion, with a mean GDP growth rate of 1 year, which translates to 3.2%. The GDP per capita stands at $65,000, and the country ranks high in financial freedom (Financial Freedom Index: 80). South Korea, with a GDP of $1.6 trillion, has a 1-year average GDP growth rate of 2.7%. The GDP per capita is $31,000, and its financial freedom index is 70. Taiwan, while not explicitly mentioned, is known for its strong semiconductor industry. The IMF has raised its GDP growth forecast. Finland has a GDP of $276.7 billion, but specific GDP growth figures are not specified. The GDP per capita is $41,000, and other details such as financial freedom [6].

III. RELATED WORKS

Cooper and Zmud assert that R&D results in the creation of innovations and innovation, which in turn boosts the quality of production and the modernization of current knowledges. The framework included the concepts from the models established by Canh et al. The idea suggests that individuals in an economy should acquire and develop skills and knowledge in order to achieve economic progress. The buildup of human capital not only speeds up commercial progress, but also creates motivations for study and breakthroughs. Engelbrecht asserts that both human capital and R&D have a significant effect of the Total Factor Productivity (TFP). Both international and domestic R&D have a substantial influence on TFP. However, in wealthier nations, the benefit of domestic R&D on development is more pronounced than minor economies.

Ballot, Fakhfakh, and Taymaz conducted research to review the implication of human and expertise capital on company efficiency in the economies of France and Sweden. Ullah, Akhtar, and Zaefarian employed the Generalized Method of Moments (GMM) as their analytical approach. The dataset used in this study entails of panel data from prominent Swedish and French corporations, from 1987 to 1993. The research included Human capital stock and R&D as a model input. Technology capital was quantified via R&D activities, whereas human capital was assessed based on the training programs provided by corporations. Gustavsson, Hansson, and Lundberg demonstrate the substantial influence of human and technology capital on a firm's productivity in Sweden and France [7].

Khan, Khan, and Khan highlight through assessing the co-integration and causal link among economic growth and R&D investment of China from 1987 to 2007 that there is clear evidence of these two variables being co-integrated, indicating the presence of a long-term relationship. According to Hu, Yang, and Chen the R&D elasticity to GDP is 0.9243, showing that a 1% increment in R&D outlay would result in a 0.9243% rise in the growth rate of GDP. Furthermore, the R&D spending has been identified as the Granger cause of GDP, providing indication that R&D expenditure is a crucial factor of economic development. Several issues are present in the empirical investigation. For instance, in the co-integration test, only one valid option is considered, perhaps leading to the exclusion of other significant options. However, this article does not have any impact on our conclusion. In order to sustain a high GDP growth rate, it is imperative for the Chinese government to persistently augment its investment in R&D and implement strategies to accelerate the adoption of advanced technologies.

Despite extensive studies on the economic growth and innovation capabilities of individual countries, comparative analyses involving Singapore, South Korea, Taiwan, and Finland remain limited. Previous research has often focused on the innovation systems and economic performance of these nations in isolation, without a comprehensive comparative approach that examines their trajectories in tandem. In addition, there is a shortage of systematic studies on the part played by R&D spending, public-private sector investments, and technological outcomes in their innovational processes. These gaps are filled by this research as it offers a comparative analysis of economic and innovation indicators and examines factors that define development, as well as an analysis of the conversion of technical knowledge into commercial innovations in the four selected developed countries.

IV. DATA AND METHODS

Research Design and Data Collection

This research utilizes a comparative research approach to study the economic growth and design competency of Finland Singapore Taiwan and South Korea. The work adopts a mixed method approach that affords a comprehensive evaluation of the performance of each country in economic development, research and development expenditure and technological outcomes [8].

Economic Indicators

The work aims at assessing economic growth and employs Gross Domestic Product (GDP) per capita as a variable to this end since the variable gives an indication of the economic well-being of each country. The economic development index for a country i at time t is the GDP per capita defined in Eq. (1).

$$Y_{it} = \frac{GDP_{it}}{Population_{it}} \quad (1)$$

where GDP_{it} refers to the GDP of nation i at time t, while $Population_{it}$ represents the population of nation iii during the same period. This metric measures the average income per capita and is useful for determining the rates of economic development between the countries. Moreover, due to variation in the cost of living, the study employs the PPP-adjusted GDP per capita. PPP-adjusted GDP is determined by the formula of PPP adjusted GDP per capita in Eq. (2).

$$\mathrm{Y}_{\mathrm{PPP}_{\mathrm{it}}} = \mathrm{Y}_{\mathrm{it}} \times \mathrm{PPP}_{\mathrm{it}} \quad (2)$$

In this equation PPP_{it} is the PPP conversion factor for nation i at time t that allows to make international comparisons of economic variables using different local currencies.

R&D Outlay

R&D expenditure is gauged in terms of the proportion of the GDP to determine the level of investment in R&D in relation to the size of economy. The R&D intensity for i at t is given by Eq. (3).

$$I_{it} = R\&D_{it}.GDP_{it} \times 100 \quad (3)$$

Here, $R\&D_{it}$ refers to the total expenditure on R&D of nation i at time t, while GDP_{it} refers to the GDP of country i at the same time. This percentage explains the share of the economic turnover that is devoted to the performance of research and development tasks. This paper also analyses the distribution of R&D outlay between the public and private sections. The level of R&D outlay of the private sector is governed by Eq. (4).

$$P_{it} = R\&D_{it}.R\&D_{total_{it}} \times 100 \quad (4)$$

where $R\&D_{it}$ is the R&D outlay by the private sector in nation i at time t, and $R\&D_{total_{it}}$ is the total R&D outlay in nation i at the same time. The idea is that this metric can help reveal the extent to which private sector investment contributes to innovation.

Patents and R&D Output

To effective evaluate the effect of R&D on the organization the study focuses on the patent granted per capita. The number of patents per capita for nation i at time t can be represented with the help of Eq. (5).

$$P_{it} = \frac{Patents_{it}}{Population_{it}} \quad (5)$$

where $Patents_{it}$ represents the number of patents issued to nation i at time t, and 〖$Population_{it}$ represent the population of country i at that time. This ratio represents the mean number of patents per person and hence is used to measure innovative output. The study also looks at the distribution of patents by organization type, to get a view of the contribution of various organizations in innovation. The percentage of patents awarded to an explicit organization is computed from the formula given in Eq. (6).

$$P_{org_{it}} = \frac{Patents_{org_{it}}}{Patents_{total_{it}}} \times 100 \quad (6)$$

where $Patents_{org_{it}}$ is the number of patents granted to an explicit organization in nation i at time t, and $Patents_{total_{it}}$ is the total number of patents approved in nation i at the same time. It assists in determining the most crucial organizations that are patenting their inventions and their role in innovation.

Comparative and Quantitative Analysis

The study employs various statistical techniques to analyze and compare the data. Descriptive statistics are used to summarize key metrics such standard deviations, means and medians of R&D outlay, and patents. This provides a snapshot of each country’s performance in economic and technological domains [9].

Correlation Analysis

To explore the relation among R&D expenditure and economic growth, Pearson's correlation coefficient is calculated using Eq. (7).

$$r = \frac{\sum(X_i-\bar{X})\,(Y_i-\bar{Y})}{\sqrt{\sum(X_i-\bar{X})^2\sum(Y_i-\bar{Y})^2}} \tag{7}$$

where X_i and Y_i represent the variables being compared (e.g., R&D intensity and GDP per capita), and $\bar{X}$ and $\bar{Y}$ are their respective means. This coefficient quantifies the direction and strength of the linear relation among economic development and R&D expenditure.

Regression Modeling

To evaluate the effect of R&D outlay on economic advancement, a reversion model is used as shown in Eq. (8).

$$\mathrm{GDP}_{\mathrm{it}} = \beta_0 + \beta_1 + \beta_2 + \epsilon_{\mathrm{it}} \tag{8}$$

In this model, β_0 is the intercept, β_1 represents the constant for total R&D expenditure, β_2 represents the coefficient for R&D outlay, and ϵ_{it} is the error term. This model helps quantify the relation among R&D investment and GDP per capita, isolating the effects of R&D costs on economic development. Detailed case studies of firms such as Samsung, Nokia, and HTC provide qualitative insights into how these organizations contribute to national design capabilities. The analysis focuses on their innovation strategies, market success, and impact on their respective national economies. An analysis of national policies and government programs, for example, the Finnish TEKES and Singapore's Economic Development Board, reveals how these programs promote technologization and provide for the enhancement of design competency. The assessment seeks to evaluate the impact of these policies in fostering innovation and the resultant technological developments [10].

Validity and reliability

To enhance the credibility of the study, the study has incorporated information from the Organization for Economic Co-operation and Development (OECD) the International Monetary Fund (IMF) and national statistical agencies [11]. In order to cross check, the findings, data triangulation technique is used and to make the regression models more reliable, statistical tests like F-test and t-tests are used. It also recognizes that there may be factors such as data accessibility problems and biases arising from national reporting. Furthermore, although the regression models have given useful results it is seen that direct causal effects of R&D expenditure on design capability may be confounded by other factors such as differences in industrial sectors and country specific conditions.

V. RESULTS AND DISCUSSION

Singapore, Finland, Taiwan, and South Korea have been chosen for the relative comparison of design aptitude because of similarities in characteristics. Firstly, these countries are very small in size. Secondly, their economies have seen fast development over the last three decades. Lastly, they are all actively working towards the establishment of knowledge-based economies.

Economic Advancement

Each of the four nations has seen remarkable economic development in recent decades, although along distinct trajectories. The economics and development of Korea have traditionally been controlled by Chaebols, which are major conglomerates owned by prominent families, like Hyundai, Samsung, LG, and others.

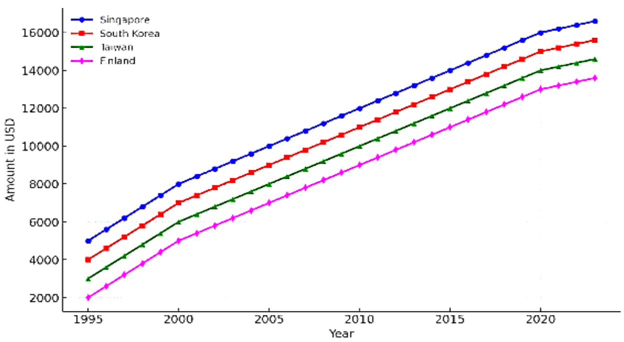

Fig 1. GDP Per Capita According to PPP in USD

The Korean administration vigorously shielded Chaebols from both local and international race in their formative years, enabling them to expand fast in terms of both size and financial resources. This was achieved via contract manufacturing and the production of imitation goods for export. The recent economic prosperity of Finland was heavily dependent on the triumph of Nokia. Taiwan's economic impetus was driven by its contract manufacture of computers for American fabless companies, semiconductors, and electronic elements. The prosperous expansion of Taiwan's IT industry may be attributed to the modularization tendency of electronic goods and computers that emerged in the 1990s. This movement led to the outsourcing of components and the vertical fragmentation of IT-related companies.

Singapore's economic growth is a direct outcome of its effective implementation of large-scale logistical operations, known as “Entrepot plus,” as well as its strong presence in banking, aviation, and real estate industries. Furthermore, it was propelled by the activities of multinational firms based in Singapore. The government's substantial expenditures in human capital and physical infrastructure, such as training and education, together with the implementation of business-friendly laws and services, were the key factors that led to the successful occurrence of this final item. The Economic Development Board (EDB) of Singapore has effectively and significantly contributed to the attraction of multinational firms from across the world to establish operations in Singapore. In the 1970s, multi-national companies (MNCs) first introduced labor-intense, low-cost engineering occupations. Subsequently, in the 1980s, they shifted towards high-skill engineering and capital-intensive activities. Singapore's current achievements have already positioned it as the Asian nation with the maximum GDP per capita in 2023, surpassing Japan by a significant margin. **Fig 1** demonstrates that Singapore has consistently attained much greater GDP per Capita than the other countries in the contrast group from the early 1990s.

R&D Expenditure

Previous economic achievements have enabled all four nations to make substantial and escalating investments in R&D, as seen by their ongoing increment in R&D expenditure as percentage of their GDP see **Fig 2**. Despite having a high GDP per Capita, Singapore's outlay in R&D is lower than the rest of the countries. The analysis of R&D spending reveals that the R&D expenditure outlay between the private and public sectors is very consistent throughout these nations. In the private sector has accounted for around 70-80% of the overall R&D outlay, as shown in **Fig 3**.

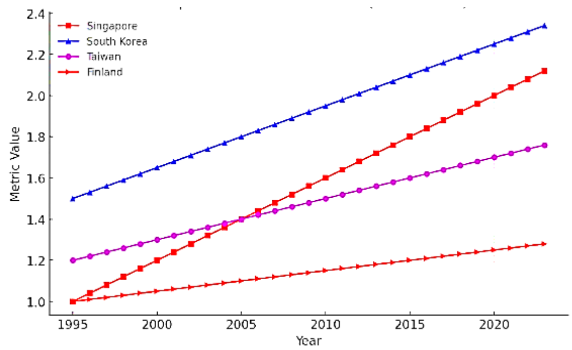

Fig 2. R&D Costs as A GDP Percentage

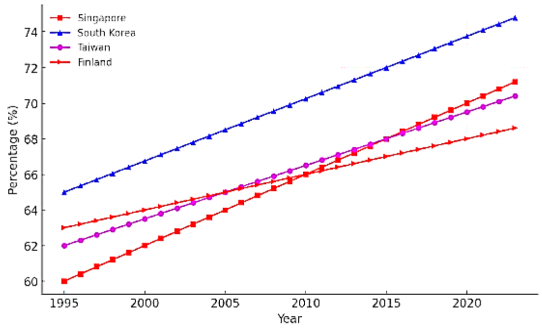

Fig 3. R&D Costs Within the Private Sector as A Proportion of The Overall R&D costs

R&D Output

All four nations have high rankings in scientific and math education, as reported in [12]. Additionally, each of these countries has successfully cultivated a knowledge foundation that is applicable to technology. Singapore has attained a notably greater quantity of engineering articles per individual see **Fig 4** compared to the other nations. South Korea's performance in this statistic is subpar, perhaps indicating concerns about the extent and adaptability of its technical foundation. Taiwan and Finland exhibit notable similarities and may be distinctly positioned between South Korea and Singapore in terms of comparison. **Fig 6** demonstrates a significant variation in ranking when comparing patents per capita contrary to GDP per capita or publications, as seen in **Fig 5**.

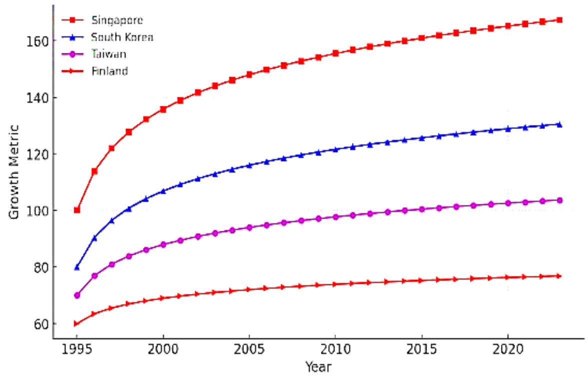

Fig 4. Engineering Publications Per a Million Individuals

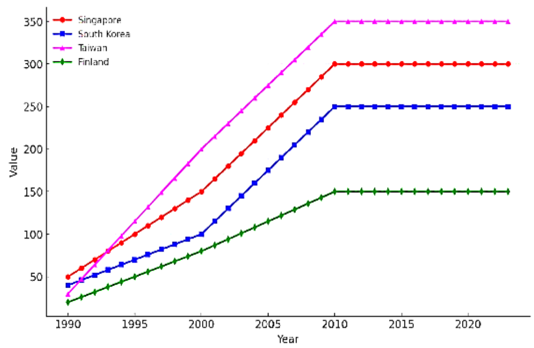

Fig 5. American Patents Per a Million Individuals

Taiwan is the most productive in this regard, followed by Finland and Korea in the middle range, with Singapore being the least productive. Taiwan's proficiency in patent applications and lackluster performance in academic publication sets it apart from Singapore's trend. These two nations have distinctly shown varying capacities in transforming proven technical expertise into commercially-driven innovations, highlighting contrasting design capabilities. An analysis of patents categorized by the firm provides further differentiation within the category. Most patents granted to Singaporean inventors are actually awarded to multinational corporations (MNCs), governmental research organizations, and universities, as shown in **Fig 6**. In contrast, indigenous enterprises in other nations are the primary producers of patents. This difference shows the significant contribution of MNCs in developing Singapore's capacity for technology-driven design. The patent landscape in Singapore has evolved over time. Initially, local enterprises saw a decrease in patent filings, but they have now reached a level comparable to multinational corporations, with each accounting for around 40% of the total. In contrast, the public sector has consistently provided around 20% of the patent filings throughout the years [13].

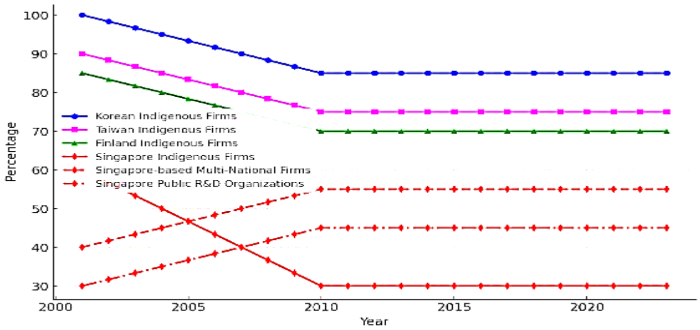

Fig 6. Percentage Distribution of Patents Granted to The Top 20 Businesses Based on Their Respective Organization Types

Table 1 provides a comprehensive list of the top five firms that have obtained patents in each nation as well as worldwide. It is evident that the four countries exhibit distinct and discernible trends in terms of patenting. Both Korea and Taiwan have seen the emergence of a group of companies that are aggressively obtaining patents in the field of electronics. By engaging in ongoing experiential learning, the Chaebols have emerged as the foremost technological innovators in Korea and are regarded as some of the most exceptional globally. Samsung obtained approximately 4,260 patents in 2023, which was second only to IBM's approximately 5,860 patents. LG, on the other hand, secured 1,450 patents, placing them in ninth position globally. Taiwan stands out due to its significantly higher number of firms engaged in patenting, as well as a larger number of firms patenting in smaller volumes compared to other countries [14].

Additionally, Taiwan's ITRI (Industrial Technology Research Institute), a public research and development organization, received approximately 460 American patent contributions in 2023, making it the second major apparent firm in Taiwan. Nokia, a Finnish company, received the majority of patents granted in Finland in 2023. Specifically, Nokia was granted 554 patents that was twenty times more than its second recipient, Metro Paper, Inc. It is substantial to note that this count does not include the patents granted to Nokia-affiliated enterprises. The patenting activity of organizations located in Singapore is around 1/50th of the volume of firms in Korea, or 1/7th of them in Taiwan. According to Ernst it appears that Korea and Taiwan may have already developed a strong design capability in the broad field of electronics. On the other hand, Finland's design capability seems to be concentrated in a single company, and there is minor evidence of Singapore developing a strong design capability.

Table 1. Top 5 Patent Administrations in Four Nations

	Rank	**Firm**	**20014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**
Singapore	1	Stats	-	-	-	-	3	3	6	20	30	85
	2	Chippae	-	-	1	3	14	26	38	27	31	44
	3	Research	1	2	1	-	2	4	13	22	31	37
	4	and Science	108	125	92	73	45	56	36	25	22	34
	5	Technology Agency Marvel International Chartered Semiconductor Micro Technologies	2	6	21	34	32	35	37	26	24	33

Taiwan	1 2 3 4 5	Hon Hai Precision Ind. Co. Industry Technology Research Institute Taiwan Semiconduct ors Manufacturi ng Co. AuOptronics Corp. Mediatek Inc.	309 219 528 - 3	191 215 445 12 1	180 205 428 39 5	216 196 455 76 22	136 159 430 104 29	231 237 459 157 104	183 224 454 176 121	278 271 355 174 151	416 376 292 234 146	572 464 405 358 223
S. Korea	1 2 3 4 5	Samsung Electronics LG Electronics Inc Hynix Semiconduct or Inc. LG Displays Co. Telecom and Electronic Research Institute	1378 245 4 - 72	127 4 335 96 - 89	125 3 404 244 - 103	151 4 474 331 - 86	156 9 461 353 - 112	230 6 683 438 - 171	258 3 665 400 - 205	332 5 774 435 268 254	339 4 104 4 584 590 304	425 9 145 0 972 715 457
Finland	1 2 3 4 5	Nokia Metro Paper ABB OY. Kone Corp. Outotee OYJ	6 10 - 11 -	24 52 5 9 -	154 55 5 10 -	256 63 3 3 -	222 46 13 10 -	403 45 19 9 -	470 29 20 14 4	420 39 14 26 9	449 26 11 33 13	554 29 29 59 21
Global	1 2 3 4 5	IBM Samsung Microsoft Corporation Canon Panasonic Corporation	3411 1446 396 1877 1440	328 8 132 8 499 189 2 154 4	341 5 131 3 499 199 2 177 4	324 8 160 4 629 180 6 193 4	294 1 164 1 746 182 9 168 8	362 1 245 1 146 3 236 8 222 9	312 5 272 3 163 8 198 3 191 0	416 9 350 2 202 6 210 7 172 4	488 7 359 2 290 1 220 0 180 6	586 6 451 8 308 6 255 1 245 6

Technology-Based Companies
Furthermore, these four nations have shown distinct tendencies in the establishment of technology-based companies.

Singapore
Singapore has only performed one national innovation survey based on the Oslo Manual. This survey took place in 1999 and focused on manufacturing and selected KIBS branches. The findings of this survey were documented in According to Kotabe around 32% of manufacturing businesses in Singapore were engaged in innovation, meaning they had launched new goods or processes in the last three years. In contrast, more than half (57%) of the companies in the KIBS sector were involved in innovation, as shown in **Table 2**. Within the manufacturing sector, product innovations were slightly more prevalent, introduced by 24.1% of companies, compared to process innovations, introduced by 22.4% of companies. However, in the KIBS sector, the opposite was true. Here, 44.4% of firms had implemented product innovations, while 49.4% had implemented process innovations see **Table 3**. The significance of the electronics cluster in the Singapore National System of Innovation (NSI) was apparent in the sectoral analysis of enterprises engaged in innovation. Within the manufacturing sector, the electronics industry had the largest percentage (68.8%) of firms that were engaged in innovation.

Similarly, within the KIBS sector, the information technology (IT) services industry had the highest percentage (73%) of companies that were engaged in innovation [15].

Table 2. Enterprises Engaged in Innovation Within KIBS And Manufacturing Sectors in Singapore in 1999

	Innovating companies (%)
Manufacturing	31.7
Chemicals	38.0
Electronics	68.8
Precision & process engineering	28.5
KIBS	56.9
Transport engineering	18.2
Market research, business management& management consultancy	58.0
IT and related services	73.0
R&D, publishing, advertising, exhibitions & conferences	70.0
Architectural, land surveying, engineering, other technical	40.0

Table 3. Enterprises In the Singapore Manufacturing and KIBS Sectors That Have Experienced Product and Process Innovation In 1999

	Product innovation	**Process innovation**
KIBS	44.4	49.4
Manufacturing	24.1	22.4

South Korea

The study, shown in **Table 4** and **Table 5**, displays the outcomes of regression analysis conducted on domestic and international technology transfer contracts. Technology and fixed-assets variables have a positive correlation with company value in domestic contracts. Nevertheless, the presence of human resources has a beneficial impact on the performance of technology transfer with other nations. Fixed assets are crucial for organizations that engage in technical licensing arrangements. Technological collaboration may have a favorable impact on company performance by influencing the technology resource variable.

Table 4. Domestic

Variable		**Dependent variable (Increased sales ratio)**							
		I		II		III		IV	
		Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error	Coefficients	Standard Error
Capital		1.241	0.0001	0.504	0.0001	0.688	0.0001	0.546	0.0001
Number of employees		-1.260	0.0001	-0.515	0.0001	-0.722	0.0001	-0.571	0.0001
Resources	Human			-0.013	4.9100	0.23	5.0350	0.204	4.9730
	Technology			0.301**	0.4570	0.294**	0.4550	-0.118	1.4540
	Fixed-Asset			0.316**	0.0380	0.343***	0.0380	0.407***	0.0400
	Process			0.026	0.0030	-0.018	0.0050	0.045	0.0050
Capabilities	Searching					-0.007	0.0890	-0.050	0.1150
	Absorbing					0.205*	0.0910	0.131	0.1090
	Openness					-0.098	0.1870	-0.190*	0.2310
Tech*Searching								0.147	1.3870
Tech*Absorbing								0.226*	0.7680
Tech*Openness								0.224*	2.0070
Industry dummies		Yes		Yes		Yes		Yes	
Adjusted R^2		0.007		0.270		0.208		0.322	
F		1.170		6.076***		5.483***		5.065***	
N		138		138		138		138	

*Notes: p < .1, *p < .05, **p < .01, ***p < .001*

Taiwan

New Technology-Based Enterprises (NTBFs) are said to have a substantial impact on promoting entrepreneurship and driving economic advancement. A vital tactic for nurturing the development of high-tech firms is the construction of scientific parks close to universities and research facilities in many nations, particularly those in Western Europe and emerging Asia. This approach is inspired by the effective advancement of NTBFs near MIT and Stanford in the U.S. The effectiveness of the park strategy may be evaluated based on several aspects, including the employment generated and the level of innovation achieved. From the perspective of R&D policy the issue of whether new NTBFs situated in parks demonstrate superior performance in terms of invention is a matter of administrative interest. In order to determine if enterprises located inside a park are more inventive, it is more suitable to compare their efficiency in R&D rather than just looking at the output of their R&D efforts.

Table 5. Foreign

Variable		**Dependent variable (Increased sales ratio)**							
		I		II		III		IV	
		Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error	Coefficient	Standard Error
Capital		0.577	0.0001	0.615	0.0001	0.609	0.0001	0.652	0.0001
Number of employees		-0.580	0.0001	-0.578	0.0001	-0.615	0.0001	-0.678	0.0001
Resources	Human			0.167*	2.5330	0.203**	2.5460	0.204**	2.5100
	Technology			0.053	0.3040	0.056	0.3170	-0.355	0.6860
	Fixed-Asset			-0.024	0.0370	0.023	0.0380	0.077	0.0380
	Process			0.025	0.0010	0.058	0.0010	0.074	0.0010
Capabilities	Searching					0.124	0.0510	0.139	0.0610
	Absorbing					0.160	0.0520	0.021	0.0640
	Openness					0.100	0.1560	0.002	0.1910
Tech*Searching								-0.002	0.6550
Tech*Absorbing								0.341*	0.6310
Tech*Openness								0.281*	1.3070
Industry dummies		Yes		Yes		Yes		Yes	
Adjusted R[1]		0.006		0.017		0.042		0.070	
F		1.218		1.378		1.746		2.042	
N		223		223		223		223	

*Notes: p < .1, *p < .05, **p < .01, ***p < .001*

Table 6. The Level of Innovative Activity of Taiwan and HSIP

	Taiwan			**HSIP**			**Taiwan/ HSIP**		
	1	2	3	4	5	6	7	8	9
	R&D (millions)	Intensity of R&D (GDP/R&D)	Innovation patents	R&D (millions)	Intensity of R&D (sales/R&D)	Innovation patents	(1)/(4) (%)	(2)/(5)	(3)/(6) (%)
2010	71547	1.61	398	3428	5.22	57	4.80	3.24	14.05
2011	81764	1.65	663	4203	5.40	140	5.15	3.27	21.09
2012	94827	1.73	565	4457	5.11	75	4.70	2.95	13.08
2013	103616	1.73	741	6294	4.87	108	6.08	2.81	14.49
2014	114681	1.77	667	8203	4.61	169	7.16	2.59	25.46
2015	125030	1.78	1137	12569	4.19	398	10.06	2.36	35.05
2016	137954	1.82	1392	17825	5.88	465	12.91	3.21	33.44
2017	156320	1.90	1610	23525	5.90	767	15.06	3.07	47.53
2018	176454	1.97	1597	32321	7.11	679	18.33	3.58	42.44
2019	190519	2.05	2138	35453	5.44	946	18.60	2.65	44.19
2020	197630	2.05	3833	40063	4.20	1773	20.28	2.05	46.28
2021	204973	2.16	6476	46000	6.47	2244	22.45	2.99	34.64
2022	224427	2.30	5682	46529	5.77	2015	20.74	2.50	35.47
2023	240819	2.44	6398	50403	4.99	2270	20.92	2.04	35.45

Table 6 presents the R&D efforts and patent activities of enterprises located inside the High-Technology Industrial Parks (HSIP) in comparison to other firms in Taiwan. **Table 6** serves to demonstrate the level of innovation shown by on-park firms. Columns (1)– (3) show the patterns of total R&D outlay, R&D power, and the quantity of patents granted to Taiwanese citizens. Evidently, all of these new initiatives have a consistent upward trajectory. The level of R&D spending has grown by almost three times, namely from $72 billion in 2010 to $240 billion in 2023. The rising pattern in expenditures of R&D demonstrates the significant endeavors linked to technological and scientific advancement in Taiwan, endeavors that are crucial for enhancing industrial capabilities. The proportion of R&D outlay to GDP increased from 1.6% to 2.5% in 2010 to 2023, respectively. The number of patents utilizations for innovations by residents increased significantly from 400 to 6400 in 2010 to 2023, respectively [16].

Finland

Industrial and technology policy finds a compelling focal point in New Technology-Based Firms (NTBFs). This may be attributed to two primary factors. First, NTBFs are thought to have a variety of positive effects on social cohesion and economic development. Furthermore, it is widely acknowledged that it is feasible to deliberately stimulate the development of NTBFs by direct policy interventions In the NTBF industry has a significant potential for generating jobs. According to **Table 7**, high technology enterprises with less than 500 people accounted for 70% of the entire workforce in these sectors, but only generated 25.7% of the total yearly revenues. The 7 enterprises in the biggest size class, while they make up just 0.2% of the total number of organizations and employ 34.6% of the entire personnel, account for 71.4% of the whole sales in these segments.

Table 7. Employee Count in Low-Tech and High-Tech Industries In 1986 and 1993

Size classes	**High-tech**		**Δ**	**Low-tech**		**Δ**	**Sales per employee KFIM 1993, NTBFs**
	1986	1993		1986	1993		
0-4 employees	4,104	6,153	50%	14,129	13,152	-7%	330
5-9 employees	4,342	5,532	27%	10,333	10,806	5%	417
10-19 employees	5,377	4,834	-10%	19,880	14,292	-28%	409
20-49 employees	6,832	5,755	-16%	37,456	27,276	-27%	530
50-99 employees	4,865	6,215	28%	27,901	23,905	-14%	668
100-199 employees	5,411	6,337	17%	36,114	39,383	9%	655
200-499 employees	8,464	11,353	34%	46,298	30,916	- 33%	534
500-999 employees	7,961	4,150	- 48%	29,172	38,111	31%	660
1000- employees	18,311	26,588	45%	222,333	99,925	- 55%	2,481
Total	65,667	76,917	17%	443,616	297,766	-33%	1,202

Recommendations from a Design Perception

The measurements have shown utility (with constraints) in uncovering parallels and differences in design capacity across countries in an economic environment. Furthermore, all four nations have seen consistent growth in all numerical indices. However, there is a noticeable difference in several indices, which reveals the development of distinct design talents. For example, Taiwan excels in patenting but performs average in publishing articles, which sets it apart from Singapore in both aspects. This comparison suggests that Taiwan has developed a more robust capacity for design, such as the conversion of knowledge into innovations, compared to Singapore. This is evident, at least in some technical fields. Moreover, the findings have also shown the distinct paths that these nations have taken in developing their design capabilities.

VI. CONCLUSION

This paper has utilized a comparative analysis of four countries namely Finland, Taiwan, South Korea, and Singapore to provide noteworthy insights into the forces shaping growth and innovation in developed economies. The findings emphasize the importance of R&D spending in supporting technological development and economic growth while indicating the differences in the private and public sectors among the countries. With strong manufacturing industries and large private expenditures in R&D, Taiwan and South Korea are now ahead of the curve in terms of technological production and global rankings [17]. On the other hand, Singapore's emphasis on winning multinational corporations and establishing the right environment for innovation has pushed the country's innovation despite slightly less domestic R&D spending. The fact that Finland is almost evenly split between public sector investment in R&D and a highly educated workforce also supports the position that a well-coordinated and balanced approach is necessary to support innovation. This paper establishes that, although every country has its distinct approaches based on the characteristics of its system, the translation of technical know-how into market goods remains a fundamental process. This research support the need for a more complex approach to the analysis of the various innovation policies and economic strategies that can be used to strengthen the national systems of innovation. This research not only contributes to the literature on comparative innovation but also provides policy insights for governments seeking to enhance economic and innovation outcomes in their environments.

CRediT Author Statement
The author reviewed the results and approved the final version of the manuscript.

Data Availability
No data was used to support this study.

Conflicts of Interests
The author(s) declare(s) that they have no conflicts of interest.

Funding
No funding agency is associated with this research.

Competing Interests
There are no competing interests

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