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SOUTHEAST ASIAN NATIONS' REGIONAL COMPETITIVENESS: AN EXPLORATION THROUGH GREY RELATIONAL ANALYSIS

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Abstract. This study aims to explore the comparison of the regional competitiveness of the nations targeted by Taiwan's New Southbound Policy and the key indicators that influence regional competitiveness. Through comparative analysis between each other, we will further select countries and regions that are most suitable for investment and exchange. Regional competitiveness describes the ability of various economies to compete for resources or markets in a region. Exploring regional competitiveness allows the best nations for investment to be identified so that unnecessary costs and losses may be avoided. This paper proposes a multiple attribute decision making method, grey relational analysis (GRA), for solving this kind of problem. This study investigates the regional competitiveness of various nations using competitiveness rankings obtained through the ranking of grey relational ordinals. The study seeks to identify critical factors underlying regional competitiveness. The study variables are grouped into four major factors: economy, human resources, technology, and trade capability. The results reveal that India, Singapore, and Australia are nations with regional competitive advantages. Labor force and technology are indispensable factors for enhancing regional competitiveness. ASEAN countries have greater regional competitiveness than South Asia or Australia and New Zealand.

Keywords: regional competitiveness, ASEAN countries, grey relational analysis.

JEL Classification: C30, F63, R11, R58.

Introduction

In 2009, developed and emerging nations all over the world agreed to use the Group of Twenty (G20) as a platform for dialogue on major international economic issues and to replace some of the functions of the Group of Eight (G8) (Shorr & Wright, 2010; Wade, 2011). This move has highlighted two major trends among world powers. First, they understand that

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discussions on global economic cooperation cannot be based solely on the opinions of developed nations. As emerging economies grow stronger, they too have their own right to make decisions on various issues related to global economic cooperation (Hanson, 2012). Second, emerging nations have earned the right to speak for themselves for the first time. In the future, emerging nations will acquire more right to speak up (Fidrmuc & Korhonen, 2010). Global competition entities or strategies are not based on a nation's level of development but, rather, on free trade agreements (FTAs) (Baier & Bergstrand, 2007) and regional trade agreements (RTAs) among competitive regions or economically integrated nations (Akman, 2016). In Europe, the concept of regional integration emerged in the 1950s (Doidge, 2016).

After a series of events, regional cooperation has clearly become increasingly structured (Amin, 2010). The development of regional economic activities started with the establishment of three trading blocs, namely the European Union (EU) (Caporaso, 2018), North American Free Trade Area (NAFTA), and Association of Southeast Asian Nations (ASEAN). The development of these trade blocs characterise the process of regional economic integration (Appendini & Bislev, 2016).

The economies of Southeast Asia and South Asian countries are rapidly expanding, and their consumption capacity is significantly increasing. These countries also actively participate in global and regional economic integration, which allows them to expand their market advantages (Yang, 2018). Furthermore, they control a considerable portion of the domestic demand market. Consequently, they have emerged as bright spots of global economic growth. The total GDP of the ten ASEAN countries and the six South Asian countries is currently US$ 4.2 trillion and US$ 2.7 trillion, respectively, with populations of 620 million for the former and 1.7 billion for the latter. Their average annual economic growth rates are 4.9% and 7.4%, respectively, exceeding the global economic growth rate of 3.1%. ASEAN and South Asia countries will produce an emerging middle class with solid consumption capacity, forming a domestic demand market with substantial business opportunities resulting from economic growth.

The New Southbound Policy is a strategic plan formulated based on economic development needs, mutual benefit, and diversified development principles. It may also help to promote regional economic integration. In the new international environment, Taiwan should make structural adjustments to its Asia–Pacific economic and trade strategy, including its foreign strategy to support domestic industrial transformation and economic growth. We share resources, qualified people, and create a new cooperation model for mutual benefit by promoting the connections of economy and trade, science and technology, and cultural ties between Taiwan and 18 countries, including ASEAN, South Asia, New Zealand, and Australia.

Regional competitiveness refers to the ability of various economies in a region to form and demonstrate competition for resources or markets in the process of market competition (Camagni, 2017; Kitson et al., 2004; Onyusheva et al., 2018). It can also be explained as the ability of a region to optimise the allocation of resources in a larger region compared to other similar regions (Kobayashi et al., 2017).

Regional competitiveness can be divided into three levels: basic competitiveness, core competitiveness, and leading competitiveness. Basic competitiveness is the level of competitiveness resulting from basic factors such as natural resources, labour, capital, facilities, and

technology. A region's core competitiveness (i.e., a region's industrial competitiveness) refers to the overall strength of industries in the region and its development potential within its economic system and environment. A region's leading competitiveness refers to the region's level of economic radiation and aggregation ability. Competitiveness is divided into company and national levels. Enterprise competitiveness is defined as the ability of an enterprise to exist as an independent economic entity in the competitive market environment, make full use of external resources and the environment in limited market resource allocation, and constantly improve its own attributes to achieve relative competitive advantages as well as realize the virtuous circle of sustainable development (Best, 2001).

With the globalization of technical and industrial competition, nations are experiencing significant changes to their competitive advantage and the international trade structure, prompting each nation to value international indicators and evaluation results regarding national competitiveness (Öz, 2019). In addition, international indicators are widely used in national policy and performance analysis. One objective of international indicators is to highlight a nation's relative position in international competition (Coccia, 2019). Other objectives include identifying a nation's strengths and weaknesses as a reference for policy formulation. Currently, the annual competitiveness reports released by the World Economic Forum (WEF) and the International Institute for Management Development (IMD) provide the most comprehensive and reliable assessment of international competitiveness. However, the WEF and IMD use different competitiveness assessment frameworks and indicators due to their different perspectives on national competitiveness, which leads to different rankings. In particular, the WEF's global competitiveness reports highlight national competitiveness as a nation's ability to increase its economic growth rate for sustainably improving national living standards and attach importance to a nation's long-term growth potential, in alignment with prospective prospects research topic requirements (Haseeb et al., 2019).

Moreover, the competitiveness assessment criteria adopted in the WEF reports indicate that the factors determining national competitiveness are complex and multi-faceted. Based on the WEF reports, the present study aims to use a multi-criteria decision-making assessment method to identify clear leading indicators for measuring national competitiveness, or more precisely, relative national competitiveness. These indicators are essential, as they represent the long-term drivers of national progress and do not serve as controversial cross-national comparative indicators.

A wide range of evaluation methods may be used for multi-criteria decision-making, including many hybrid methods to evaluate the performance of various countries (Torkayesh & Torkayesh, 2021). For instance, fuzzy analytic hierarchy process, a type of analytic hierarchy process (AHP), when combined with the technique for order preference by similarity to ideal solution (TOPSIS), can be used to evaluate the environmental sustainability of cities (Chou et al., 2019). Alternatively, AHP combined with grey relational analysis (GRA) can evaluate the optimal information collection system (Yang & Chen, 2016). AHP, combined with the VIseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) technique, can establish key performance indicators for sustainable development (Suganthi, 2018). Multi-criteria decision-making techniques can help managers control business operations strategies. All these methods have been widely adopted in various fields.

In particular, GRA assumes a non-functional sequence model and does not generate results in conflict with qualitative analysis; its advantages include being computationally simple, and not requiring large amounts of data or data normalization (Koçak & Özer, 2021). This method can be flexibly applied to various fields. It allows extremely efficient policy formulation and value creation under limited-resource conditions, thereby avoiding nations' wasteful over-investment in global competition. Given the above context, the present study proposes using GRA to explore different nations' resource allocation strategies and performance concerning regional competitiveness (Ikram et al., 2021). Regional competitiveness is indispensable to the economic development of a nation or even a region. Therefore, this study investigates the regional competitiveness of various nations. The contributions of this study can be summarised into three points as follows.

First, most previous studies on regional competitiveness employ multivariate regression to analyse correlations with regional competitiveness (Bilbao-Terol et al., 2017; Camagni, 2017; Kitson et al., 2004), but grey relational analysis (GRA) is rarely used as the research method. GRA can be used to identify ambiguities in the system model and information incompleteness (Hsiao & Hsiao, 2016). Some of the indicators are formulated from questionnaire surveys, which, per se, face a validity problem due to, for instance, answer biases and sampling errors. Through GRA, information quantity and quality form a continuum from a total lack of information to complete information. In this study, GRA is used to analyse the key factors behind a nation's regional competitiveness. It can effectively deal with "uncertainties", "multivariate inputs", "discrete data", and "data incompleteness" (Hsiao & Hsiao, 2016; Sun et al., 2015; You et al., 2017).

Second, using regional competitiveness analysis and comparison as the basis for selecting investments and trade dealings is considered to be more effective for regional investments. The pace of integration is slower, and the economic scale relatively smaller, in ASEAN than in the EU and NAFTA. However, ASEAN is primarily composed of emerging and developing economies (Loo, 2018; Onyusheva et al., 2018), so it has high potential for growth in the future. Moreover, it is the region that EU nations and the United States aim to integrate with most closely.

Lastly, although regional competitiveness primarily refers to the ability to acquire resources or allocate resources between regions, all parties select suitable industries for development using the principle of comparative advantage under the concept of regional division of labour (Bristow, 2010; Kitson et al., 2004). According to the concept of regional development, national boundaries are no longer the criteria for dividing regions; instead, regions are delineated according to the level of regional integration. Regional integration started late in Asia but has now gathered momentum, with ASEAN playing a leading role mainly because the countries in the region (Te et al., 2018; Zhang & Matthews, 2019), including China, South Korea, and Japan, have not been able to successfully negotiate FTAs. Nonetheless, these three nations have successfully signed FTAs with ASEAN. With the effects of integration expected to manifest in the future, ASEAN has a more advantageous strategic position in trade. However, the strengths and weaknesses of each ASEAN nation are yet to be clearly determined. This study compares and analyses the competitiveness rankings of ASEAN, South Asia, and the New Zealand–Australia region to provide a reference for ASEAN countries to investigate their advantages and disadvantages and improve their regional competitiveness.

This study is divided into the sections. Section 1 explores the history and development of regional competitiveness, and Section 2 discusses the research methodology of this study. Section 3 features the empirical analysis of this study and, using GRA, analyses the key factors influencing a nation's economic growth, ranks each nation by regional competitiveness using GRA and examines its development strategies. The last chapter presents the conclusions drawn from this study.

1. Literature review

1.1. Discussions on regional competitiveness

In economics, competitiveness is studied from both micro-economic and macro-economic perspectives (Kobayashi et al., 2017). In the former, competitiveness is regarded as the economic ability and survivability of a company or firm, whereas the latter focuses on exploration and comparison of competition between nations or regions (Guerrero et al., 2016; Onyusheva et al., 2018). Regional competitiveness, or the competitiveness of nations in a region, is studied from a macro-economic perspective (Bowen et al., 2018; Camagni, 2017). Various definitions of competitiveness have emerged, each aiming to describe a nation's or region's competition potential more comprehensively than the others (Bilbao-Terol et al., 2017; Camagni, 2017). In macroeconomics, one of the most important definitions of competitiveness at the national level is the Global Competitiveness Index (GCI) developed by WEF, which defines competitiveness as "the set of institutions, policies and factors that determine the level of productivity of a country" (Kalim et al., 2019). In EU's Sixth Periodic Report on the Regions, competitiveness is defined as "the ability to generate, while being exposed to international competition, relatively high income and employment levels" (European Commission, 1999). Meanwhile, regional competitiveness arises from the ability to maintain environmental, social, and cultural stability in the face of market competition (Guerrero et al., 2016; Kitson et al., 2004).

Regional competitiveness refers to the ability of the region to distribute resources and provides services within its area (i.e., its ability to integrate economic, social, technological, and environmental aspects). Hussain, Szczepańska-Woszczyna, Kamarudin, Anwar, and Saudi (2021) examined the impact of social globalization dimensions of interpersonal, informational, and cultural globalization on microfinance institutions' financial and social efficiency. The results showed that cultural globalization positively correlated with social efficiency, demonstrating that a global trading culture improves the abilities and technical skills related to labor development. This study also posited that the Cobb-Douglas production theory explains the impact of social globalization on social globalization efficiency.

When studying the relationship between industry clusters and cooperative competition or regional competitiveness, regional competitiveness is defined as the ability of a specific region to optimise resource allocation, effectively attract and allocate resources, and expand beyond the region in terms of resources better than other regions engaged in international or domestic competition. Following the scholars cited above, this study defines regional competitiveness as 'the ability of a region or nation to create better advantages than other regions or nations, and maintain or attract more resources while facing international changes, thereby developing advantages within the region'.

1.2. Regional competitiveness for ASEAN countries

Having been in existence for over 40 years since its founding in 1967, ASEAN has grown from five founding nations to ten member nations, including the Indochinese Peninsula and Southeast Asian nations (Loo, 2018). ASEAN has a total area of nearly 4.46 million square kilometres and a total population of over 600 million people. With the establishment of the ASEAN Economic Community at the end of 2015, ASEAN has become the third largest market with a population larger than that of NAFTA and EU and a GDP of US$2.5 trillion, thus becoming the sixth largest economy in the world (Te et al., 2018). The Indian Ocean has the busiest sea lanes in the world and holds numerous strategic positions and trade chokepoints (Kobayashi et al., 2017). Mahrinasari, Haseeb, and Ammar (2019) examined the association between environmental degradation and trade openness in ASEAN countries. They analysed the effect of trade liberalization on carbon dioxide emissions in Malaysia, Indonesia, Singapore, Thailand, and the Philippines. The results indicated that trade liberalization has a significant positive impact on carbon dioxide emissions and that a higher degree of trade liberalization is associated with poorer environmental conditions. According to the study, trade liberalization is an essential factor that ASEAN countries should prioritize to reduce environmental degradation. Hence, it is recommended that governments enhance trade based on renewable and green technology.

Surrounding this ocean is South Asia, with a land area of 4.48 million square kilometres and a total population of 1.68 billion people, accounting for approximately 23% of the global population. South Asia has a GDP of US$2.6 trillion, and thus is a large economy. ASEAN and South Asia are composed of developing nations (Duval & Feyler, 2016). Over the past 10 years, these nations have generally maintained an economic growth rate of more than 4%, which means that they are currently in the high economic growth stage. These nations form a huge market, which has gradually become the largest investment destination in the world. Meanwhile, New Zealand and Australia, located in the vast ocean in the southern hemisphere, together have a land area of over 8 million square kilometres, a population of approximately 29 million, and a total GDP of over US$1.5 trillion.

Both nations are the most developed in the southern hemisphere. Australia is the world's largest exporter of wool, aluminium, and coal, as well as the world's third-largest exporter of liquefied natural gas, wheat, and cotton, because of its high agricultural and mineral production capacity, while New Zealand, with its natural beauty, attracts tourists from around the world who bring in large amounts of foreign exchange. Both New Zealand and Australia have high levels of economic development due to their historical background. Their development has not slowed down despite their small populations; therefore, both nations offer great business opportunities. Overall, ASEAN and South Asia have a large amount of human resources and low labour costs, coupled with rising purchasing power year by year, thus forming a huge domestic market in the region (Przygoda, 2017). At the same time, both New Zealand and Australia are endowed with abundant natural and tourism resources, which bring in large amounts of foreign exchange. In summary, understanding the pros and cons of the New Southbound market is of great significance for international investment. Hence, a study the New Southbound market is of paramount importance (Yang, 2018). This study seeks to identify key factors underlying regional competitiveness. Other research on this topic

has employed multivariate regression to analyse correlations with regional competitiveness. However, grey relational analysis is a seldom-used approach despite its ability to effectively address "uncertainties", "multivariate inputs", "discrete data", and "data incompleteness". For this propose, this study investigates the regional competitiveness of various nations using competitiveness rankings obtained through the ranking of grey relational ordinals.

1.3. Measurement of regional competitiveness

As seen in the previous chapter, regional competitiveness covers many aspects. Every scholar uses a different factor to measure regional competitiveness. Ginevičius, Nazarko, Gedvilaitė, and Dacko-Pikiewicz (2021) indicated that an essential condition of national competitiveness is a country's economic development. The study in question compared the varying degrees of economic development dynamics across different countries using Gini coefficients determined from the Lorenz curve as an essential characteristic of such dynamics. It revealed that Italy had a moderate degree of economic development, while Sweden had a relatively low degree of sustainability. Hussain, Haseeb, Kamarudin, Dacko-Pikiewicz, and Szczepańska-Woszczyna (2021) investigated the asymmetric impact of globalization, economic growth, and natural resources on the ecological footprint, given an environmental Kuznets curve in Thailand. The results showed that globalization and natural resources were significant and non-linear in Thailand. Furthermore, the presence of an environmental Kuznets curve was tested in the study, with the results substantiating the existence of an inverted U-shaped curve in Thailand's economy.

A nation's ability to attract foreign investments and maintain steady economic growth primarily depends on its regional competitiveness (Camagni, 2017; Guerrero et al., 2016). International studies on regional competitiveness emerged in the 1970s. According to Porter, national (or regional) competitiveness can be regarded as the ability to attract and maintain economic activities while maintaining or improving standards of living (Caporaso, 2018; Dima et al., 2018). However, the World Economic Forum (WEF) defines competitiveness as "a series of institutional and economic policies that maintain high pace of economic growth" (Schwab, 2009). Some scholars have argued that regional competitiveness is the force that supports regional survival and development (Caporaso, 2018; Dima et al., 2018). Regardless of these viewpoints, economic development is the main rationale for measuring regional competitiveness (Kobayashi et al., 2017). This study investigates this market because ASEAN and South Asia have low labour costs and high economic growth. By exploring the regional competitiveness of these nations, one can avoid unnecessary costs and losses by identifying some of the best nations for investment.

Porter (1993) describes how to strengthen national competitiveness using factor conditions, demand conditions, related and supporting industries, and firm strategy, structure, and rivalry. Factor conditions refer to the nation's position in regard to factors of production, such as skilled labour or infrastructure, while demand conditions relate to the productivity and service capability of domestic industries. Huang and Hergül (2014) used three groups of factors–basic requirements, efficiency enhancers, and innovation factors. Each group is composed of the following factors: education, labour market efficiency, environmental protection (efficiency enhancers) and innovation (innovation factor). Charles and Díaz (2017)

set five pillars (economy, firms, government, infrastructure, and people) to investigate regional competitiveness in Peru. Djogo and Stanisic (2016) established six basic indicators of competitiveness (6BIC): balance of current account, unemployment rate, annual cost of salary per worker, external debt, economic growth rate, and investment rate.

WEF constructs the GCI every year to rank competitiveness. This index is divided into three sub-indexes, namely basic requirements, efficiency enhancers, and innovation and sophistication factors, with 12 pillars used as the basis for measurement (Roy, 2018). Similar to WEF, IMD also publishes the WCY every year to assess competitiveness, based on economic performance, government efficiency, business efficiency, and infrastructure; these factors are further divided into 20 sub-factors (Kramulová & Jablonský, 2016).

Taking a cue from the literature, briefly described above, and considering the difficulty of obtaining data, this study developed 4 indicators (factors), namely "economy", "human resources", "technology", and "trade capability", as well as 11 sub-indicators (sub-factors), to measure regional competitiveness.

2. Methodology

2.1. Research sample and research period

This study investigated the factors influencing regional competitiveness of the Nations in Taiwan's New Southbound Policy. Data were sourced from publicly available statistics on the official websites of the World Bank (WB), the World Intellectual Property Organisation (WIPO) and International Monetary Fund (IMF). This study used data on 18 nations, including 10 ASEAN countries, 6 South Asian nations, Australia, and New Zealand, for the period 2008 to 2016. The variables in this study are grouped into 4 major factors, namely "economy", "human resources", "technology", and "trade capability", which comprise 11 sub-factors. The sample consists of 198 observations.

2.2. Operational definition of variables

In this study, 11 sub-indicators, used as the research variables, were grouped into 4 major indicators, namely economy, human resources, technology, and trade capability. The definition of each variable is provided in Table 1.

Table 1. Definition of variables

Indicator	Sub-indicator	Code	Definition	Source	Reference
ECONOMY	Gross Domestic Product	GDP	The market value of all goods and services produced by the people of a nation in a particular unit of time (usually one year).	WB	Kuznets (1988), Stone and Ranchhod (2006), Charles and Diaz (2017), WEF Garelli (2014)

End of Table 1

Indicator	Sub-indicator	Code	Definition	Source	Reference
	Gross Domestic Product per Capita	GDPC	The gross domestic product divided by the population of the nation.	WB	Kuznets (1988), Stone and Ranchhod (2006), Charles and Diaz (2017), WEF Garelli (2014)
	Gross Domestic Product Growth Rate	GGR	A nation's GDP growth trend.	WB	Garelli (2014)
HUMAN RESOURCES	Labour Force	L	The population with the potential of being employed, including the employed and unemployed population.	WB	Kuznets (1988), Stone and Ranchhod (2006)
	Unemployment Rate	U	The ratio of employed people to the total labour force.	WB	Kuznets (1988), Stone and Ranchhod (2006)
	Gross National Income per Capita	GNPC	The average annual income of each citizen.	WB	Charles and Diaz (2017)
TECHNOLOGY	High-Tech Product Exports	T-E	The quantity of high-tech products exported, measured in millions of US$.	WB	Charles and Diaz (2017)
	Number of Patents	P	The number of patents whose technology the state has published and granted patent rights after verifying that they meet patent act requirements.	WIPO	Huang and Hergül (2014), Charles and Diaz (2017)
TRADE CAPABILITY	Foreign Direct Investment	FDI	Economic investments made locally by foreign firms to make profits.	IMF	WEF Garelli (2014)
	Import Volume	I	The quantity of commodities and goods imported from abroad (or places of production) into the domestic market.	WB	WEF Garelli (2014)
	Export Volume	E	The quantity of commodities produced or processed in the nation that are exported to foreign markets.	WB	WEF Garelli (2014)

Note: WB – World Bank; WIPO – World Intellectual Property Organisation; WEF – World Economic Forum; IMD – Institute for Management Development; IMF– International Monetary Fund.

2.3. Grey relational grade

Grey relational grade is an important pillar in grey theory, and is function is to calculate the measures between discrete series (You et al., 2017). A space that satisfies both factor space and comparability conditions is known as "grey relational space", and it is described as $\{P(X);\Gamma\}$, where $\{P(X)\}$ is the subject and Γ is the measure. There are four axioms for $\{P(X);\Gamma\}$.

i. Normality:

$$0<\gamma(x_i,y_j)\le 1\forall,\forall j. \tag{1}$$

The space is "completely related" when $\gamma(x_i,x_j)=1$ and "completely unrelated" when $\gamma(x_i,x_j)=0$.

ii. Duality symmetric:

When there are only two series in the factor set, the following must hold:

$$\gamma(x_i,x_j)=\gamma(x_j,x_i). \tag{2}$$

iii. Wholeness:

When the series has three or more groups,

$$\gamma(x_i,x_j)\ne\gamma(x_j,x_i). \tag{3}$$

iv. Closeness:

$|x_i(k)-x_j(k)|$ is the main control item of the entire $\gamma(x_i(k),x_j(k))$. Therefore, the magnitude of the grey relational grade must be related to this item. If a function $\gamma(x_i,x_j)\in\Gamma$ that satisfies all the four axioms above can be found in the grey relational space, then $\gamma(x_i,x_j)$ is a grey relational grade.

2.3.1. Derivation of traditional grey relational grade

$\gamma(x_i,x_j)$ is the formula for quantitatively measuring grey relational grade in the grey relational space. When determining grey relational grade, if only $x_0(k)$ can be the reference series while other series are comparison series, it is known as "localised grey relational grade". If any series $x_i(k)$ of all the series can be reference series, it is known as "globalised grey relational grade".

(1) Grey Relational Coefficient

In the grey relational space $\{P(X);\Gamma\}$, there is a series

$$x_i(x_i(1),x_i(2),\cdots,x_i(k))\in X, \tag{4}$$

where $i=0,1,2,3,\cdots,m$, $k=1,2,3,\cdots,n\in N$, namely

$$\begin{aligned}
x_0&=(x_0(1),x_0(2),\cdot,\cdot\cdot,x_0(k)),\\
x_1&=(x_1(1),x_1(2),\cdot,\cdot\cdot,x_1(k)),\\
x_2&=(x_2(1),x_2(2),\cdot,\cdot\cdot,x_2(k)),\\
&\vdots=\vdots\\
x_m&=(x_m(1),x_m(2),\cdot,\cdot\cdot,x_m(k)).
\end{aligned} \tag{5}$$

The grey relational coefficient of localised and globalised grey relational grades is defined as follows:

i. Local: When only one series, $x_0(k)$, is the reference series, and the other series are comparison series.
ii. Global: When any series $x_i(k)$ of all the series can be reference series.

(2) Deng's Grey Relational Coefficient

The grey relational coefficient is defined as

$$\gamma\left(x_i(k), x_j(k)\right) = \frac{\Delta_{\min} + \varsigma\Delta_{\max}}{\Delta_{oi}(k) + \varsigma\Delta_{\max}}, \tag{6}$$

where $i = 0, 1, 2, 3, \cdots, m, k = 1, 2, 3, \cdots, n\ j \in I$,

x_0 is the reference series, and x_i is a specific comparison series.

$\Delta_{oi} = \| x_0(k) - x_i(k) \|$: x_0 is the absolute value of the kth difference between x_0 and x_i.

$$\Delta_{\min} = \forall j \in i \forall k \| x_0(k) - x_j(k) \|; \tag{7}$$

$$\Delta_{\max} = \forall j \in i \forall k \| x_0(k) - x_j(k) \|. \tag{8}$$

ς is the distinguishing coefficient, where $\varsigma \in [0, 1]$ (this value can be adjusted as required).

(3) Distinguishing Coefficient, ς

In the grey relational coefficient, the distinguishing coefficient ς mainly serves for comparison between the background value and the object to be tested. The value of the distinguishing coefficient can be adjusted as required. In general, its value is set at 0.5. However, to increase the difference in the results, the value can be adjusted according to actual requirements. It is mathematically proved that the value of the distinguishing coefficient will change only the magnitude of the relative value but will not affect the ranking of the grey relational grades.

(4) Grey Relational Grade

When determining the grey relational coefficient, the average value of the grey relational coefficient is used as the grey relational grade.

$$\gamma\left(x_i, x_j\right) = \frac{1}{n}\sum_{k=1}^{n} \gamma\left(x_i(k), x_j(k)\right). \tag{9}$$

However, in the actual system, the importance of each factor to the system is not completely consistent. Therefore, to address the actual situation, where the weights of various factors are not equal (Sun et al., 2015), we extend the definition of grey relational grade in the equation above as follows:

$$\gamma\left(x_i, x_j\right) = \sum_{k=1}^{n} \beta_k \gamma\left(x_i(k), x_j(k)\right), \tag{10}$$

where β_k represents the normalised weight of factor k, which will be decided by the user. However, it must satisfy the condition $\sum_{k=1}^{n} \beta_k = 1$. When the weights are equal, these two equations will be equal.

(5) Grey Relational Ordinal

According to the definition of grey theory, the traditional grey relational grade indicates the degree of association between two series and is used in qualitative analysis (Hsiao & Hsiao, 2016). Therefore, the most important message here is the ranking of grey relational grades by value, where the grey relational grades of *m* comparison series relative to the same reference series are ordered by the magnitude of values obtained, so as to form a magnitude relation known as the grey relational ordinal. The mathematical model of grey relational ordinal is expressed as follows:

In reference series x_0 and comparison series x_i,

$x_0 = \left(x_0(k) \right)$, $x_i = \left(x_i(k) \right), k = 1, 2, 3, \cdots, n, i = 1, 2, 3, \cdots, m,$

where, if $\gamma(x_0, x_i) \geq \gamma(x_o, x_j)$, the grey relational grade of x_i to x_0 is greater than the grey relational grade of x_j to x_0, which is represented as $x_i \succ x_J$, known as the grey relational ordinal between x_i and x_j.

2.3.2. Quantification of grey relational grade

When both the numerator and denominator in Eq. (11) are divided by $\Delta_{\max}$, the equation of grey relational coefficient in traditional grey relational grade is as follows:

$$\gamma\left(x_0(k), x_i(k)\right) = \frac{\frac{\Delta_{\min}}{\Delta_{\max}} + \varsigma}{\frac{\Delta_{oi}(k)}{\Delta_{\max}} + \varsigma}. \tag{11}$$

At this time, let $\gamma\left(x_0(k), x_i(k)\right) = z$, $\frac{\Delta_{\min}}{\Delta_{\max}} = x$, $\frac{\Delta_{oi}(k)}{\Delta_{\max}} = y$, where $x, y, z \in [0, 1]$, the equation can be simplified as follows:

$$z = \frac{x + \varsigma}{y + \varsigma} \Rightarrow \varsigma = \frac{zy - x}{1 - z}. \tag{12}$$

The mathematical formula of the grey relational coefficient is primarily used to make the corresponding adjustment to $\Delta_{\max}$ with the distinguishing coefficient, so that the grey relational grade can satisfy the same level of comparability and proximity to the four axioms. Since the formula of the traditional grey relational grade is a linear combination of grey relational coefficients, its quantified nature cannot be completely established but can only be used for ranking. Therefore, the operating range of Eq. (12) is worth discussing. It is found that the key to overcome this problem is the presence of the distinguishing coefficient. Hence, the distinguishing coefficient needs to be further discussed.

2.3.3. Modified grey relational grade for determining the distinguishing coefficient

The fitness value of the distinguishing coefficient is determined so that the grey relational grade can be subjected to quantitative analysis. After the subject to be analysed is given, $\frac{\Delta_{\min}}{\Delta_{\max}}$ must be a specific value, so $\Delta_{\max} - \Delta_{\min}$ is used as the horizontal axis of the membership function, and the value of $\Delta_{oi}(k)$ is the corresponding criterion. The output is the magnitude of the distinguishing coefficient, which is used to determine the fitness value of

the distinguishing coefficient. Here, the value of distinguishing coefficient is obtained using the maximum and minimum criteria in fuzzy theory.

i. $\{\vee\}$: Obtain the maximum value of $\Delta_{oi}(k)$.

ii. $\{\vee\}$: Obtain the minimum value of $\Delta_{oi}(k)$.

In this study, four methods, namely $\{\underset{\max}{\vee}\ \underset{\max}{\vee}\}$, $\{\underset{\max}{\vee}\ \underset{\min}{\wedge}\}$, $\{\underset{\min}{\wedge}\ \underset{\max}{\vee}\}$, $\{\underset{\min}{\wedge}\ \underset{\min}{\wedge}\}$, are used for analysis.

2.3.4. Modified grey relational grade with distinguishing coefficient equal to 1

For the modified grey relational grade in current studies, the distinguishing coefficient is primarily taken as one, so that the formula of the traditional grey relational grade is converted into the following:

$$\Gamma_{0i} = \Gamma\left(x_0(k), x_i(k)\right) = \frac{\Delta_{\min} + \Delta_{\max}}{\overline{\Delta}_{oi}(k) + \Delta_{\max}}, \tag{13}$$

where $\overline{\Delta}_{oi}(k)$ is redefined as

$$\overline{\Delta}_{oi}(k) = \left\{\frac{1}{n}\sum\nolimits_{k=1}^{n}\left[\Delta_{oi}(k)\right]\right\}. \tag{14}$$

2.3.5. Grey relational ordinal in the globalised grey relational grade

In the globalised grey relational grade, since each series can be a standard series, ranking can be carried out using the eigenvector method after determining all the grey relational grades. The relevant steps are described as follows:

$$\begin{aligned}
x_0 &= \left(x_0(1), x_0(2), \cdot, \cdots, x_0(k)\right),\\
x_1 &= \left(x_1(1), x_1(2), \cdot, \cdots, x_1(k)\right),\\
x_2 &= \left(x_2(1), x_2(2), \cdot, \cdots, x_2(k)\right),\\
&\vdots = \vdots\\
x_m &= \left(x_m(1), x_m(2), \cdot, \cdots, x_m(k)\right).
\end{aligned} \tag{15}$$

If each series is used as a standard series once and other series are comparison series, a $m \times m$ matrix can be obtained after arranging all the grey relational grades computed. This matrix is known as the grey relational matrix, *R*.

$$R_{m\times m} = \begin{bmatrix} \gamma_{11} & \gamma_{12} & \cdots & \gamma_{1m} \\ \gamma_{21} & \gamma_{22} & \cdots & \gamma_{2m} \\ \vdots & \vdots & \ddots & \gamma_{11} \\ \gamma_{m1} & \gamma_{m2} & \cdots & \gamma_{mm} \end{bmatrix}. \tag{16}$$

After the matrix is generated, each element is the value of the grey relational grade, and the method for determining the weights is as follows:

i. Establish a matrix with the desired target, $\left[R\right]_{m\times m}$.

ii. Determine the eigenvalues of matrix *R*, where $AR = \lambda R$.

iii. Determine the eigenvectors of matrix *R*, thus forming:

$$P^{-1}RP = \mathrm{diag}\left\{\lambda_1, \lambda_2, \lambda_3, \cdots, \lambda_n\right\}. \tag{17}$$

iv. Determine the eigenvector corresponding to the maximum eigenvalue, λ_{max}, where the value of each corresponding element in the eigenvector is its weight (obtain its absolute value).

Such weights can represent the evaluation and comparison of the importance of elements in the main diagonal of the grey relational matrix to the system. On the other hand, the ranking of their magnitude can be used as the criterion for determining the best series in the system.

3. Results

3.1. Analysis of regional competitiveness rankings for each year

(1) Set the reference series for standardisation:

Since each indicator has different measurement methods, it is not appropriate to carry out comparative research, and it is not possible to draw the right conclusions. Therefore, data must be standardised during GRA. The grey relational generating method for each indicator is shown in Table 2.

Table 2. Grey relational generating methods

Indicator		Generating Method	Reason
Economy	GDP	The larger the better	Positively related to the economic indicator
	GDPC	The larger the better	Positively related to the economic indicator
	GGR	The larger the better	Positively related to the economic indicator
Human Resources	L	The larger the better	Positively related to the human resource indicator
	U	The smaller the better	Negatively related to the human resource indicator
	GNPC	The larger the better	Positively related to the human resource indicator
Technology	T-E	The larger the better	Positively related to the technology indicator
	P	The larger the better	Positively related to the technology indicator
Trade Capability	FDI	The larger the better	Positively related to the trade capability indicator
	I	The larger the better	Positively related to the trade capability indicator
	E	The larger the better	Positively related to the trade capability indicator

(2) Determine the grey relational coefficient:

The maximum and minimum differences are determined after standardising the values. Assuming that the distinguishing coefficient is 0.5, the coefficients of correlation between each indicator of each country for different years and the reference series are determined as shown in Appendix 3.

(3) Determine the grey relational grade:

As the coefficient of correlation is the degree of association between each indicator series and the reference series, there should be several values. Besides, overly scattered information does not favour holistic comparison, so the coefficients of correlation in each curve need

to be into a single value – the average of these coefficients of correlation – to express the degree of correlation between each indicator series and the reference series and obtain the grey relational ordinals. Then, the series are arranged in the order of degree of association as shown in Table 3.

Table 3. Comparison of grey relational grades and grey relational ordinals among different nations (Unit: %; ranking)

Nation	2008	2009	2010	2011	2012	2013	2014	2015	2016
BRN	68.6 7	73.5 5	70.8 8	71.9 8	72.8 8	73.7 8	74.9 8	77.1 14	76 15
KHM	68.3 8	72.4 9	70.1 9	73.5 6	74.7 6	75.1 4	78.2 4	82.5 4	83.2 4
IDN	68.9 5	73.5 4	71.4 6	73.8 5	74.8 5	74.8 5	76.5 6	81.5 6	80.2 10
LAO	64.1 13	70.5 11	65.9 14	68.4 13	69.4 14	70.5 13	73.1 13	78.1 13	77.5 12
MYS	69.3 4	73 7	73.1 5	74.1 4	74.6 7	74.3 7	78 5	82.1 5	81.3 6
MMR	63.3 16	69.3 13	66.1 12	67.4 16	69.4 13	72 10	73.6 11	78.4 11	77.4 13
PHI	64.5 12	69.2 14	67.4 10	67.5 15	70.5 11	71.4 11	73.5 12	79.2 10	80.3 8
SGP	87.7 3	92.4 2	100 1	99.5 1	99 1	100 1	100 1	100 2	100 2
THA	68.7 6	72.9 8	73.8 4	72 7	76.5 4	74.4 6	74.2 10	80.7 9	80.3 9
VNM	65.1 11	71.3 10	67.3 11	69.4 11	70.1 12	71.1 12	74.4 9	81.4 7	80.4 7
BTN	66 10	69 15	66 13	69.9 10	68.1 16	66.5 18	69.1 18	76.8 15	76.2 14
BGD	63.5 15	69.5 12	65.6 16	67.9 14	68.8 15	69 14	72 14	78.3 12	78.3 11
IND	90.1 2	100 1	97.4 2	98.2 2	96.7 2	98.8 2	100 2	100 1	100 1
NPL	63.1 18	68.4 16	64.6 18	65.4 18	67 18	66.7 17	70.6 15	74.8 18	72 18
PAK	63.8 14	67.8 18	65 17	66.5 17	67.5 17	67.5 15	70.4 16	76.6 16	75.9 16
LKA	63.2 17	68.1 17	65.8 15	69 12	71 10	66.8 16	70.2 17	76.4 17	74.9 17
AUS	91.7 1	92.1 3	90.2 3	94.8 3	95.6 3	93.2 3	93 3	93.5 3	95.5 3
NZL	67.8 9	73.3 6	70.9 7	71.8 9	72.6 9	72.4 9	75.6 7	81.1 8	81.5 5

Note: BRN – Brunei, KHM – Cambodia, IDN – Indonesia, LAO – Laos, MYS – Malaysia, MMR – Myanmar, PHI – Philippines, SGP – Singapore, THA – Thailand, VNM – Vietnam, BTN – Bhutan, BGD – Bangladesh, IND – India, NPL – Nepal, PAK – Pakistan, LKA – Sri Lanka, AUS – Australia and NZL – New Zealand.

Table 3 shows that the research results using changes in grey relational grade every year, where the higher the value, the higher is the degree of association with the reference series, and thus the higher the regional competitiveness. Then, regional competitiveness rankings are obtained based on the ranking of grey relational ordinals.

Overall, the grey relational grade of each nation has increased steadily, indicating that regional competitiveness has maintained growth. In terms of ranking changes, Cambodia, Myanmar, the Philippines, Vietnam, Bangladesh, and New Zealand have experienced positive growth in regional competitiveness during the nine-year period, while Brunei, Indonesia, Malaysia, Thailand, and Bhutan have demonstrated negative growth in regional competitiveness within the same period. Meanwhile, the regional competitiveness of Laos, Nepal, Pakistan, and Sri Lanka have remained largely unchanged.

3.2. Analysis of indicator weights for each year

Figure 1 is plotted according to the changes in the weights of various sub-indicators for each year, where the higher the weight of a sub-indicator, the greater its impact on regional competitiveness. The analysis results are explained as follows.

As shown in Figure 1, the weights have been changing constantly between 2008 and 2016 but have remained largely unchanged in general. The regional competitiveness sub-indicators with the top three highest weights are labour force, high-tech product exports, and number of patents. However, the weight of unemployment rate should not be underestimated as a sub-indicator. According to yearly changes, the unemployment rate even surpassed all other sub-indicators in terms of weight and turned out to be the most important sub-indicator in 2009, 2014, and 2015.

From the perspective of the four major factors, human resources and trade capability are the two most important factors influencing regional competitiveness, followed first by economy and then technology. Further investigation shows that the most important regional competitiveness sub-indicator is labour force, with an average weight of 9.47%, while the least influential variable is GDP, weighted on average by 8.54%.

The results of the indicator classification show in Figure 2 that the ranking of the four indicators was roughly stable during the research period, with the order being economy, trade capability, human resources, and technology. This indicates that the economy has always been the most critical indicator for research subjects under the New Southbound Policy.

The results for trade capability show that countries in the South China Sea need foreign capital investments to develop their trade activities to maintain national competitiveness. The advantages of human capital traditionally recognized by the public are not particularly highlighted in the issue of national competitiveness. Finally, as per the evaluation, focusing more on improving competitiveness in science and technology should be a major research priority in the future.

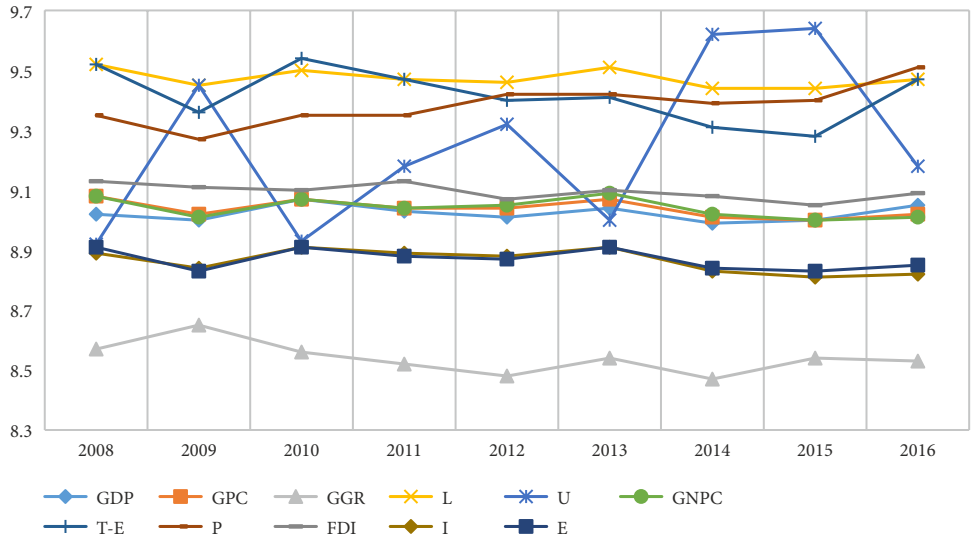

Figure 1. Indicator weights from 2008 to 2016

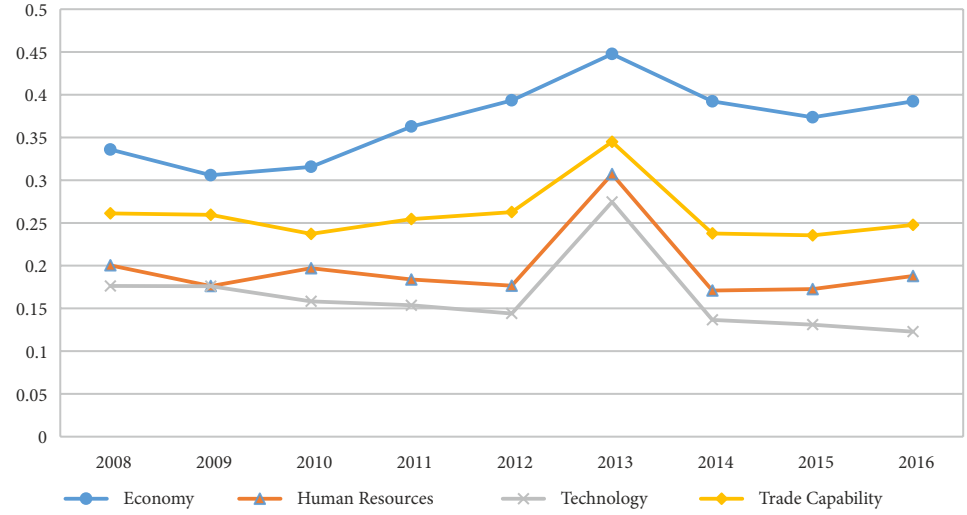

Figure 2. Indicator weights by four dimensions

3.3. Analysis of indicator weights for each nation

Table 4 shows the weight of each sub-factor for each nation, which is determined according to the grey relational grades. It is probably not surprising that Singapore, India, and Australia are in a three-way tie regarding the results. Singapore has a longstanding stable domestic and international political environment compared to other countries. Given that breakthroughs in international cooperation agreements are unlikely, enterprises struggle to effectively exploit their advantages in aspects like talent, innovation, and entrepreneurial spirit. They are prone to miss the opportunities brought about by the rise of emerging mar-

kets. Even if individual enterprises can confront the trends and challenges of globalization, they are often held back by political restrictions and traditional legal standards and barriers. The Singaporean government's efforts to support the business environment and service industry or reward development and marketing are laudable. Other countries would benefit from imitating Singapore to formulate policies that promote technological upgrading and industrial transformation.

From a national perspective, this empirical study found that India is the most regionally competitive nation in the three regions. Ranking the weights of various indicators, we found that the main regional competitiveness sub-indicators are labour force, number of patents, and high-tech product exports. For example, in 2016, India had a labour force of 512 million people, exceeding the total labour force of all other nations in the three regions (i.e. 495 million people). Moreover, India owned 25,800 patents, double those of Australia and four times those of Singapore. Besides, India ranked fourth in terms of high-tech product exports among all nations in the three regions. These factors play a key role in India's rise as the most regionally competitive country among all the nations in the three regions. In addition, as capital and technology from foreign investors contribute to economic development and

Table 4. Comparison of weights of various sub-indicators for each nation

Nation	GDP	GPC	GGR	L	U	GNPC	T-E	P	FDI	I	E	Mean
BRN	0.009	0.647	0.305	0.001	0.037	0.695	0.001	0.001	0.001	0.011	0.020	0.157
KHM	0.008	0.017	0.701	0.017	1.000	0.016	0.001	0.001	0.026	0.020	0.016	0.166
IDN	0.455	0.064	0.620	0.247	0.042	0.056	0.042	0.030	0.261	0.346	0.369	0.230
LAO	0.006	0.024	0.858	0.007	0.157	0.025	0.001	0.001	0.009	0.007	0.007	0.100
MYS	0.161	0.183	0.495	0.028	0.066	0.174	0.457	0.114	0.159	0.399	0.444	0.244
MMR	0.030	0.021	0.721	0.050	0.265	0.018	0.001	0.001	0.034	0.019	0.011	0.106
PHI	0.135	0.043	0.608	0.083	0.059	0.054	0.176	0.022	0.060	0.159	0.144	0.140
SGP	0.150	0.906	0.415	0.006	0.075	0.888	1.000	0.275	0.852	0.931	1.000	0.591
THA	0.209	0.100	0.300	0.081	0.234	0.094	0.266	0.078	0.154	0.474	0.520	0.228
VNM	0.084	0.028	0.658	0.109	0.097	0.029	0.110	0.022	0.163	0.253	0.238	0.163
BTN	0.001	0.044	0.729	0.001	0.071	0.040	0.001	0.001	0.006	0.002	0.001	0.081
BGD	0.081	0.016	0.693	0.126	0.052	0.017	0.001	0.004	0.030	0.076	0.051	0.104
IND	1.000	0.028	0.774	1.000	0.057	0.026	0.102	0.994	0.631	0.993	0.777	0.580
NPL	0.010	0.012	0.439	0.031	0.081	0.012	0.001	0.001	0.001	0.014	0.004	0.055
PAK	0.124	0.020	0.400	0.124	0.037	0.023	0.002	0.009	0.041	0.097	0.051	0.085
LKA	0.036	0.059	0.622	0.017	0.046	0.055	0.001	0.013	0.013	0.040	0.027	0.084
AUS	0.736	1.000	0.281	0.025	0.041	1.000	0.034	0.677	0.790	0.571	0.510	0.515
NZL	0.010	0.012	0.439	0.031	0.081	0.012	0.001	0.001	0.001	0.014	0.004	0.055
AVG.	0.180	0.179	0.559	0.110	0.139	0.180	0.122	0.124	0.180	0.246	0.233	0.205

Note: BRN – Brunei, KHM – Cambodia, IDN – Indonesia, LAO – Laos, MYS – Malaysia, MMR – Myanmar, PHI – Philippines, SGP – Singapore, THA – Thailand, VNM – Vietnam, BTN – Bhutan, BGD – Bangladesh, IND – India, NPL – Nepal, PAK – Pakistan, LKA – Sri Lanka, AUS – Australia and NZL – New Zealand.

employment promotion, the central and state governments of India actively attract foreign investments and provide various investors to encourage foreign firms to set up production facilities in India.

Compared to India, Singapore (with approximately 3 million people) has a much smaller labour market. However, Singapore has the highest high-tech product exports among all nations in the three regions, almost equal to the total high-tech product exports from all other nations in the three regions (US$120 billion from Singapore versus US$140 billion from all other nations in the three regions). Furthermore, Singapore ranks third in terms of number of patents among all nations in the three regions, though it does not have as many patents as India. Singapore has advanced technologies and infrastructure, a high-quality labour force, appropriate immigration laws, and efficient mechanisms to assist in driving entrepreneurship. Moreover, Singapore ranks fifth among all nations in the three regions in terms of unemployment rate, which is only 1.8%. With all these advantages, Singapore has held the top two positions in the regional competitiveness rankings of the past decade.

Likewise, Australia's labour market (with approximately 12 million people) is not as large as India's, but the country has the highest gross national income per capita and GDP per capita among all nations in the three regions. Moreover, Australia ranks second in terms of number of patents among all nations in the three regions, occupying the top three positions in the regional competitiveness rankings of the past decade.

It is noteworthy that Cambodia is not endowed with a large labour market (approximately 9 million people) or high income (US$1,000 in GDP per capita and US$1,100 in GNI) and ranks low in terms of high-tech product exports and number of patents among all nations in the three regions. However, Cambodia ranks fourth in the regional competitiveness rankings for two reasons. First, Cambodia has an extremely low unemployment rate – its average unemployment rate has remained at only 0.21% from 2008 to 2016s. Second, Cambodia has a high GDP growth rate – as much as 6.1% on average from 2008 to 2016. As a result, Cambodia has been able to stand out among all nations in the three regions and become one of the most regionally competitive nations.

This study further investigated changes in the weights of regional competitiveness sub-indicators. It was found from these changes that of the two key indicators, human resources accounted for 27.76% of all weights – the most critical sub-indicator, labor force, had an average weight of 9.47% – and unemployment rate recorded an average weight of 9.25%, the fourth highest among all sub-indicator weights. Although Cambodia, Laos, and Myanmar have an abundance of young and middle-aged workers, education is not widely available in these nations, resulting in low education and training efficiency among workers. Therefore, these nations are only able to supply unskilled or low-skilled labor.

The analysis of sub-factors showed that although the technology was weighted by only 18.8%, its sub-indicators, namely high-tech product exports and the number of patents, had the second and third highest of all indicator weights, respectively, only lower than that of the labor force. Therefore, both are relatively important indicators, representing the development of national technology and positively affecting regional competitiveness. For nations with higher levels of development, such as Malaysia, Indonesia, and Thailand, high-tech workforce and skilled labor are essential to industrial upgrading, while lack of such workforce will lead

to stagnant industries. Nations with lower levels of development, such as Cambodia, Laos, and Myanmar, can only supply low-skilled labor, bringing the industrialization process to a standstill.

Compared with the results of this study, the Global Competitiveness Index published by the World Economic Forum (WEF), and the IMD World Competitiveness Yearbook by the International Institute for Management Development (IMD) both rated Singapore as the most competitive country. Australia was ranked third by both sources, one place away from its ranking in this study. India's rankings were relatively inconsistent, respectively, sitting at sixth and seventh place. India was ranked as such because of the disadvantages in its investment climate identified in an analysis of the national conditions of the countries targeted by the New Southbound Policy. Such disadvantages include inadequate infrastructure and quality of education, government bureaucracy, persistent political stalemate, ever-growing private debt, and weak public finances. The world's top three credit rating agencies, Standard & Poor's (S&P), Fitch, and Moody's, have retained India's current sovereign rating at the lowest investment grade. Despite being the seventh largest economy globally, India is in a dire financial situation. It is also a domestic demand-led economy dependent on energy imports that records a trade deficit. Overall, India's unfavourable economic situation has placed it in an inferior position in competitiveness. As the current study did not include infrastructure, quality of education, and government culture, India was ranked relatively higher in terms of regional competitiveness.

The results of this study can be used to understand the different competitive advantages of each country. The table shows that the advantage shared by Singapore and Australia is their ability to attract large amounts of foreign investment. Singapore is unique in its performance in technological creativity. On the other hand, India has demonstrated its strong competitiveness in patent rights. By further breaking down the four facets, a more precise analysis of the competitiveness of each country can be made. The results can be used to implement the New Southbound Policy with precise directions for cooperation and policy recommendations.

3.4. Analysis of regional competitiveness among the ASEAN, South Asian Nations, New Zealand, and Australia

Regional competitiveness can not only describe the competitiveness of a nation but also closely demonstrate that of a region (Camagni, 2017; Onyusheva et al., 2018). These nations are worth discussing as they are situated in three different regions with different advantages and geographic locations (Duval & Feyler, 2016; Onyusheva et al., 2018). Therefore, this study investigates not only the regional competitiveness of each nation in the New Southbound Policy but also that of the three regions.

Table 5 shows the grey relational grades of the three regions, determined according to the GRA procedure. The regional competitiveness of the three regions, namely ASEAN, South Asia, and Australia–New Zealand, differ from that of each nation in the three regions. By region, ASEAN has the highest regional competitiveness, followed first by South Asia and then the Australia–New Zealand region.

Table 5. Grey relational grades of the three regions

Regions	2008	2009	2010	2011	2012	2013	2014	2015	2016
Economy									
ASEAN countries	0.260	0.209	0.268	0.294	0.338	0.324	0.341	0.298	0.328
South Asian Nations	0.271	0.260	0.227	0.297	0.298	0.351	0.306	0.309	0.315
Australia and New Zealand	0.477	0.448	0.452	0.497	0.543	0.668	0.530	0.514	0.534
Human Resources									
ASEAN countries	0.175	0.142	0.180	0.161	0.150	0.151	0.138	0.137	0.158
South Asian Nations	0.114	0.094	0.112	0.099	0.097	0.159	0.091	0.092	0.103
Australia and New Zealand	0.312	0.293	0.299	0.291	0.283	0.611	0.284	0.289	0.303
Technology									
ASEAN countries	0.126	0.137	0.126	0.126	0.128	0.131	0.134	0.138	0.120
South Asian Nations	0.088	0.095	0.093	0.094	0.093	0.150	0.095	0.095	0.095
Australia and New Zealand	0.315	0.296	0.256	0.240	0.211	0.543	0.180	0.161	0.153
Trade Capability									
ASEAN countries	0.218	0.224	0.242	0.226	0.241	0.247	0.241	0.245	0.247
South Asian Nations	0.170	0.178	0.150	0.153	0.144	0.255	0.150	0.161	0.173
Australia and New Zealand	0.396	0.376	0.319	0.385	0.403	0.533	0.322	0.300	0.323

According to the analysis of weights, the top three indicators of regional competitiveness are high-tech product exports, gross national income per capita, and labour force. Of the major factors influencing regional competitiveness in ASEAN, South Asia, and the Australia–New Zealand region, the main one is human resource followed by trade capability, economy, and technology in that order.

Australia and New Zealand were the best performers in all four categories. However, it is worth noting that the performance on the technology indicator has been decreasing year on year, indicating a deterioration in patent and research performance. Technology and R&D have always been important indicators of national competitiveness.

This study further compares ASEAN countries and South Asian nations. The results show that ASEAN countries outperformed South Asian nations on all indicators except the economic indicator. The performance of ASEAN countries on the economy and trade capability indicators has shown a slow rise. If ASEAN countries fail to strengthen their factor conditions such as infrastructure, human resources, and knowledge resources, other countries may be crowded out during the competition for international capital. Therefore, they should exercise caution when choosing their economic development strategies during economic reforms. Considering that integration of the ASEAN region is beneficial to economic development, efforts should also be made to enhance intra-regional trade, evaluate each country's industrial advantages, and develop an intra-regional division of labor to boost the international competitiveness of their industries.

Moreover, the performance of ASEAN countries and South Asian nations on the human resource and technology indicators remains stagnant. Although Malaysia, Vietnam, Thailand, and the Philippines, will gradually reduce their reliance on the natural resource industry as

their economies develop or transform and shift their focus to the abundance of human resources and the effective accumulation of knowledge resources instead. Ever since the school of neoclassical economics incorporated human resources as part of the production process and a subject of discussion, the quantity and quality of human resources have always been a key determinant of a country's industrial competitiveness. Recently, however, the growth rate of labor force participation has been slowing down, most drastically in Thailand and Vietnam. Comparatively, Malaysia has seen a relatively subdued decline. This outcome may be reflective of the fact that recently Malaysia's labor market has still been growing or expanding its labor demand continuously, thus attracting an ever-growing working-age population to participate in the labor force. Conversely, Thailand and Vietnam's labor markets may have been saturated or seen a decline in labor demand.

Emerging nations have rising consumption levels and make large-scale infrastructure investments with the aim of thoroughly adjusting their economies and enhancing national competitiveness through better infrastructure. In the future, infrastructure will lead to two major effects. First, traffic and transportation costs in the region will reduce, enhancing production competitiveness. Second, convenience and standard of living in the region will improve with infrastructure maturity, increasing talent mobility. Hence, emerging nations have recently made large-scale infrastructure investments, which will contribute to future competitiveness.

Conclusions

Existing studies on assessing national competitiveness have several shortcomings. There are many nation-specific factors as nations have distinctive characteristics, or they are at different developmental stages, or governmental actions differ. However, these factors have not been considered in extant studies. As a result, cross-national comparison of national competitiveness in terms of international competitiveness indicators is inappropriate. Moreover, the results of cross-national comparison do not provide clear implications. For instance, they fail to indicate the factors or characteristics that cause a nation to rank high or low. The comparison results do not provide a clear benchmark target and policy/strategy direction.

Frequent changes in the selection and weight of international indicators have led to significant changes in the international rankings of nations over time. Some of the indicators are formulated from questionnaire surveys, which, per se, face a validity problem due to, for instance, answer biases and sampling errors. This study's objective is to establish a GRA-based, multi-criteria decision-making assessment method to identify leading competitiveness indicators, to provide a policy and strategy-planning instrument for target and performance management for each nation.

As a niche for Taiwan to strengthen its partnership with New Southbound countries, the policy strives for bilateral or multilateral cooperation opportunities. In terms of regional connectivity, the policy encourages institutionalized bilateral and multilateral cooperation and international cooperation to form partnerships with New Southbound countries. By observing changes in regional competitiveness from three perspectives, namely capital movement, infrastructure, and technology exchange, one can observe three directions that will enhance the competitiveness of emerging economies in the future: capital flows to emerging nations,

governments' efforts to drive infrastructure construction, and improving technological level through mergers and acquisitions. Has implications of this study are possible to enhance the need to promote a regional dynamic of innovation and innovation policies on the need to promote regional innovation systems.

According to the findings of this study, which concerns the regional competitiveness of various nations, India and Cambodia have relatively high potential as both nations are currently in the high economic growth stage and spare no effort in economic and trade development. India has a huge labour market with relatively low labour costs (compared to China's rising wage levels), which is highly favourable for industrial development. Moreover, India's labour market is almost equivalent to that of the entire South Asia region. On the other hand, Cambodia has an almost zero-loss labour force due to its low unemployment rate. Through the exchange of 'people', Cambodia can not only seek new exports in international economic and trade exchanges but also enhance its economic and trade capabilities, thereby expanding its investments in the three regions. Qualitative changes in regional competitiveness have three major implications. First, from the perspective of factors of production, qualitative changes in various factors reveal that the competitiveness of emerging markets will continue to increase in the future. Second, by the looks of regional integration, market structures cannot be divided by national boundaries, and all factors of production will flow into the region. Third, the role of nations is becoming increasingly important in integration, and regional development will depend on whether governments have adequate ability to create an advantageous platform.

This study primarily investigated the regional competitiveness of nations in three regions and attempted to assess regional competitiveness using different indicators. However, this study has its limitation. It could only analyse data from 2008 to 2016 considering the difficulty of collect data for each indicator. Extending the period of study can help assess the regional competitiveness of each nation and region in a more accurate manner. In addition, the indicators used in this study were mostly hard (i.e., quantifiable) indicators. On the contrary, the indicators provided by the two organisations that study regional competitiveness, namely WEF and IMD, are combined with multiple soft data. However, such data are not easy to obtain. Solving the problem of data acquisition will make for more accurate studies in the future.

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Conflicts of interest

The authors declare no conflicts of interest.

Data availability statement

These data were derived from the following resources available in the public domain: the official websites of the World Bank (WB) and the World Intellectual Property Organisation (WIPO).

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