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Seizing opportunities: ASEAN country cluster readiness in light of the fourth industrial revolution

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ABSTRACT

Technological advances of the fourth industrial revolution (4IR) threaten Southeast Asian countries' industrialization model and expose its workforce to the risk of substitution. Using the Dynamic Pattern Synthesis method to ascertain how Southeast Asian countries are prepared to face these risks, we have identified three clusters based on manufacturing resources and associated them to different levels of technological capabilities. While the Cluster 1 countries Cambodia, Laos and Myanmar prove the least and Cluster 3 nations Malaysia, Thailand and Vietnam the most advanced, the preparedness of Cluster 2 countries Indonesia and the Philippines shows mixed results. Our findings emphasize the importance of human capital and trade paired with strong institutions to advance technological abilities, based on which we discuss each cluster's readiness for the 4IR.

Introduction

Industrial revolutions are distinct from mere technological change, revolutionizing value generation and transforming societies as well as systems of power. Importantly, they also represent a series of events that successively build on each other. New technologies that affect industries and the infrastructure equipment used in production, the movement of goods, and the transmission of information drive industrial revolutions. As new technologies are applied, production of goods and services is altered, and so is the organization and utilization of labor in factories. Since its introduction in 2016, the concept of the "fourth industrial revolution" (4IR) has captured this idea of transformation, focusing on emerging technologies and their effects on industries and societies. The 4IR builds on information exchanges facilitated by the data-driven foundations of the previous revolution's digital technologies. However, the 4IR is significantly different; it does not represent a prolongation of the last three revolutions but is growing exponentially, combining multiple technologies and affecting entire socio-economic systems simultaneously (Schwab, 2016).

The Association of Southeast Asian Nations (ASEAN) member states collectively represent the fifth largest economy globally, with a total GDP of USD 3.2 trillion in 2019. The region is home to more than 630 million people and has been one of the most dynamic in terms of economic growth. Moreover, ASEAN's rich colonial past has created a highly diverse cultural and political environment (Secretariat, 2020). However, ASEAN membership has been no guarantee for economic success or political stability in the past. Additionally, inventions of industrial revolutions have been transforming ASEAN's manufacturing landscape. The upcoming technological transformation will not only change production of goods and services as well as organization of work in factories, but also shape the economy and society as a whole. Hereby, the association's purposely weak institutions might constitute a disadvantage in the light of an accelerated, increasingly complex, and fragmented environment brought about by the 4IR. This calls for cross-border, decisive, coordinated action and a redesign of the way it manages regional governance to address the emerging challenges ASEAN nations face.

The core argument of our paper is the advent of new technology as the industrial revolutions' driving force of transformation and advancement. Much of ASEAN's success in economic growth can be attributed to the rise of global supply chains. This transformation paved the way for foreign direct investment (FDI) by multinational companies in countries with the competitive advantage of low wages for labor-intensive manufacturing, leading to technology lending (Baldwin, 2011). Technological advancements of the 4IR, such as robotized production, threaten the advantage many ASEAN countries have been exploiting as labor is being substituted by machines. The concept of creative destruction as an alternative to lent technology shifts the focus from the role of multinationals in economic development to individuals and entrepreneurs as adapters of new technologies and drivers for change (Aghion and Howitt, 1997); (Christensen et al., 2001).

Countries that struggle to create their own technological capabilities may be unprepared to seize the emerging opportunities presented by the 4IR. In order to capture ASEAN as a highly diverse region where countries display a wide range of manufacturing resources and are at var-

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Table 1
Framing industrial revolutions.

		1st Revolution	2nd Revolution	3rd Revolution	4th Revolution
Driver:	**New technology**	Steam power	Electric power, i nternal combustion engine, and t elephone	Renewable sources of energy, i ntegrated circuits, c omputer, and i nternet	Digital: Internet of Things, artificial intelligence, big data, cloud computing, and platforms; p hysical: autonomous cars and 3D printing; b iological: genetic engineering and neuro-technology (Li et al., 2017)
	Significant invention	Power loom (1785)	Conveyor system (1913)	ARPANET (1969)	Cyber-physical systems (2006)
Impact:	**Industries**	Cast iron, steam engine, and textile	Chemical, steel, and petroleum	Electronics and computer	Multiple industries
	Infrastructure	Steam equipment	Railroad, electricity, and telephone	Digital equipment	High-speed internet and robotized equipment
	Production	Mechanical	Conveyer belt	Automated	Intelligent with dispersed equipment connected via networks
	Product		Mass		Customized
Changes:	**Economy**			Global supply chains	
	Society		Division of labor		Substitution of labor

ious stages of technological development, we search for combinations of resources a country can draw on in times of technological-induced change. Drawing on endogenous growth theories, we connect technological progress with manufacturing resources and formulate five hypotheses. We test the hypotheses by conducting a cluster analysis and allocating three levels of technological capability to the emerging patterns. Our findings emphasize the importance of human capital and trade paired with strong institutions to ensure that countries are ready for the 4IR.

The paper is structured as follows: The first section presents a theoretical framework which introduces the drivers of past and recent industrial revolutions as well as development in ASEAN countries including emerging risks resulting from the 4IR. Additionally, we derive theory-based variables. The second section proceeds with the methodology and provides an overview of the datasets. The third section illustrates the empirical findings, starting with a detailed analysis of the three resulting clusters, including their stability over time and scores for each variable. Likewise, we explore the findings related to the clusters' technological capability in detail and summarize the variables for each cluster by presenting the emerging patterns. The last section concludes with a discussion on cluster readiness.

Theoretical background

Industrial revolutions

Industrial revolutions can be defined as the emergence of "new technologies and novel ways of perceiving the world [that] trigger a profound change in economic systems and social structures" ((Schwab, 2016), p. 11). Industrial revolutions share distinct features that set them apart from industrial evolutions; in a revolution, the emerging technologies have affected industries and infrastructure equipment used not only in manufacturing but also in the movement of goods and transmission of information (see Table 1). Furthermore, the higher level of efficiency achieved by applying new technologies has lowered production and transportation costs, raised the level of product sophistication, and thereby affected people not only as consumers but also as suppliers of labor.

Before the First Industrial Revolution, most manufacturing depended on nature to supply the necessary energy. Workers produced only a limited amount of goods in cottage industries. The introduction of the power loom in 1785 illustrates the transformation of production at the time. Traditional handlooms were slow and required several operators; the power loom instead used steam-powered mechanization to carry out much of the weaving process. Mechanical production benefitted from scale effects and comparative advantage that led to the creation of the factory system and the formation of industrial cities.

Mass production expanded during the Second Industrial Revolution by improvements of the assembly line concept in 1913 with a conveyor system transporting automobiles to fixed workstations. With the division of labor and production stages taken over by the machine, the need for specialized human skills was reduced. At the same time, more affordable production costs lowered the price of automobiles substantially and made them affordable to the average person. This new system was unlike the production mode utilized before the Second Industrial Revolution, which relied on handcrafting single parts of a product first that were later brought together for final assembly.

The Third Industrial Revolution enabled the automation of industrial processes using electronics and computers. In 1969, the Advanced Research Projects Agency Network (ARPANET) developed many protocols still used for online communication today. Improvements in telecommunications facilitated the use of scale economies as well as comparative advantage and paved the way for the emergence of global supply chains.

The origins of the major technological drivers of the 4IR are clearly visible in software applications. These include tools such as the Internet of Things, artificial intelligence, machine learning, cloud computing, and platforms. Additional drivers of the 4IR are physical, in the form of autonomous vehicles and 3D printing as well as biological with breakthroughs in genetic and neuro-technologies (Li et al., 2017). The 4IR increasingly intertwines human and machine intelligence. Furthermore, the fusion of physical, digital, and biological domains with new technologies will create new abilities (Schwab, 2016). Central drivers in industrial production are cyber-physical systems, which interlink processes with domain components monitored by computer-based algorithms. By incorporating consumer data, the new production system facilitates the provision of customized products. Cyber-physical systems include human-computing interactions and machine-to-machine automation with the potential to replace human labor. The 4IR is not limited to industrial production alone but also affects the service industry. Platforms that function as information agents – matching demand and supply in an accessible manner – provide consumers with various goods and services, allowing both parties to interact and deliver feedback (Li et al., 2017).

Industrial development in ASEAN

Innovations of industrial revolutions are historically reflected in the economic and technological development in ASEAN. In this respect, the flying geese paradigm is one of the most common conceptual frameworks to explain Asia's industrial catch-up (Kasahara, 2004). According to the paradigm, countries start at distinct stages of development, and over time, each country will first gain and then lose a specific comparative advantage. In the process, countries gradually develop technological sophistication as their economies benefit from transactional links. In search of development, a follower copies the industries of advanced economies in a manner compatible with the manufacturing resources it possesses at a particular stage. Over time, efficiency and competitiveness are strengthened, and product groups whose manufacturing process can no longer be improved cease to exist. The diversification of production and increases in added value lead to prosperity through improvements in the industrial structure and exports. Some resemblances to the industrial revolution's historical development of industries – which progresses according to the flying geese paradigm from textiles to chemicals, iron and steel, automobiles, and electronics – are visible (compare with Table 1).

Modern versions of the flying geese paradigm propose that industrial products and production processes are passed on from industrialized to developing economies through FDI and global supply chains. Thus, multinational companies act as facilitators in the technological development of host economies. (Baldwin, 2011) described the emergence of global supply chains as two unbundling processes. The first happened as steamships and railways lowered transportation costs and separated the locations of production and consumption. Later, as telecommunications costs decreased, it became increasingly economical to separate manufacturing stages and unbundle factories geographically. The Third Industrial Revolution, which enabled the second unbundling, transformed how supply chains function in Asia. Digital equipment and international wage differences made it possible to separate the individual production steps, especially the labor-intensive ones, without much loss of efficiency. Interlinked supply chains created a new form of industrialization as the managerial and technical knowledge of multinationals accompanied the establishment of production processes abroad. Accordingly, the Third Industrial Revolution facilitated the profitable and competitive combination of high technology and low-paid workers.

At the same time, it became clear that the multinationals in developed nations had no interest in creating new competitors. Critics highlight that empirical evidence has provided mixed results on the effects FDI has had on local productivity (Kasahara, 2004). Even if the internationalization of supply chains involves the application of certain parts of the parent company's expertise, multinationals will avoid technology transfer wherever possible. Consequently, according to (Baldwin, 2011) advanced manufacturing activities in developing nations should be considered technology lending rather than transfer. In this way, the multinational "lends" a narrow range of technology to a producer which manufactures its low-cost product components at the required standard. This approach contributes to industrial catch-up only to a limited extent and, if so, within a narrow range and to the technological capability defined by foreign investors.

Deindustrialization risks emerge because as production activities are relocated, and labor-saving automation increases, developing countries are running out of industrialization opportunities sooner and at lower levels of income compared to early industrializers. Service-led growth is often seen as an alternative, in fact, platform businesses such as ride-hailing and e-commerce thrive in ASEAN as they increase customer experience and convenience. However, whether service-led growth is a viable path for developing ASEAN countries is uncertain. Winner-takes-all platform businesses, where foreign companies no longer face diminishing returns to scale, have the potential to drive domestic companies out of the market and stifle competition (Menon and Fink, 2019); (Lim, 2019). Additionally, formal manufacturing jobs historically have been significant drivers for economic convergence between developing and industrialized economies. Economic development thus requires a manufacturing industry for its capacity to absorb the vast amount of unskilled labor that transitions from jobs in rural and agricultural settings to urban factories, where productivity tends to be much higher. However, many of the new tradeable services that the 4IR creates will rely on information technology that is typically highly skill-intensive and does not have the same capacity to absorb low-skilled workers (Rodrik, 2016). This generates unequal employment opportunities and may result in a widening socio-economic disparity and structural unemployment if countries do not manage to upskill their population and widen access to education (Menon and Fink, 2019); (Lee and Hong, 2012). Consequently, labor is threatened by substitution and suppose ASEAN countries are not able to increase their own technological capabilities to absorb workforces, they will be constantly exposed to external risks and may not be ready to seize the opportunities presented by the 4IR.

As high technology and low-wage manufacturing is an unreliable combination for building up industrial-technological expertise in ASEAN countries, the question remains what the alternatives to lent technology are. Theories based on creative destruction highlight two possible ways forward. First, according to (Aghion and Howitt, 1992) endogenous growth model, creative destruction occurs when entrepreneurs invest in research and development processes that enhance the productivity of intermediate equipment used in the manufacturing of final goods. In this model, new product developments render previous versions obsolete, and productivity-enhancing innovations result from competition among businesses. The latter drives the pace of technological change and is a key resource for economic growth (Aghion and Howitt, 1997). Second, the advent of disruptive processes provides insights into the growth mechanisms associated with industrial revolutions. From this perspective, technologies driving inventions created during industrial revolutions are disruptive in that they deviate from the status quo and do not represent mainstream needs. During development, emerging technology improves rapidly, introduces distinctive attributes valued by consumers, and unlocks new markets. Later, technology pioneers dominate these emerging markets because incumbents lack incentives to change and innovate (Bower and Christensen, 1995).

(Christensen et al., 2001) stressed that economies soar because they are able to repeat the cycle of disruption thereby driving macroeconomic growth by rendering an economy more efficient and productive. Referring back to the flying geese paradigm, industrial upgrading also follows a process of creative destruction. According to the paradigm, imported goods may drive local businesses out of the market by being cheaper or more functional. Likewise, when the original producers lose global competitiveness, their production may be phased out. Thus, rationalization and diversification of production stimulate an economy's industrial development (Kasahara, 2004). Consequently, the disruptive power of the 4IR could itself provide growth opportunities. Enabled by emerging technologies, disruption processes could hold the key to economic development in ASEAN, constitute an alternative to technology lending, and counter the risks of deindustrialization. (Christensen et al., 2001) assumed that the crucial breakthrough for disruptive technologies would be forged at the low-end, with less demanding customers and disruptive technologies that are more likely to come from start-up businesses than from multinationals.

Manufacturing resources

To determine variables for the cluster analysis and formulate hypotheses for emerging patterns we draw on endogenous growth theories concerned with a nation's prosperity. Specifically, we elaborate on the connection between technological progress and manufacturing resources to capture broader systems of long-term technological change induced by industrial revolutions (Nuvolari, 2019). We include five categories of variables to determine country clusters with similar manufacturing resources: human capital, gross capital formation, government expenditure, FDI, and trade.

Human capital

Human capital plays a key role in productivity and in facilitating technology absorption (Barro and Lee, 2000; Krugman, 1994) credited much of the East Asian Tigers' achievements to their investment in and enlargement of access to education. Health is also a significant contributor to strengthened human capital (Muhammad et al., 2012). Healthy populations constitute productive workforces and are often associated with life expectancy at birth (Rehman et al., 2020). A higher life expectancy indicates a healthier and more productive workforce (Radelet et al., 2001). A further source of human capital is a country's demography for which we use dependency ratio as a proxy. Population growth must be accompanied by developing the quality of human capital through education; otherwise, it can become a burden to economic prosperity (Nasir et al., 2021). Results obtained by (Benhabib and Spiegel, 1994) show that human capital is essential to absorb and adapt technology from abroad for domestic needs. In line with this reasoning, (Rueda Maurer, 2017) finds significant evidence that the materialization of FDI in technological change requires sufficient high levels of education in ASEAN +3 countries.

Hypothesis 1 : A well-educated, healthy and older population is associated with higher technological capability.

Gross capital formation

Growth theories underline the importance of capital for economic prosperity, while empirical findings demonstrate that economic expansion is marked by growth in capital accumulation in Asia (Lee and Hong, 2012); (Rehman et al., 2020) and ASEAN-4 countries (Wahyudi and Jantan, 2012). By adding capital to their model of creative destruction, (Howitt and Aghion, 1998) argued that capital accumulation and innovation are complementary and equal partners in the growth process.

Hypothesis 2: Higher capital formation is associated with higher technological capability.

Government expenditure

Governments play an essential role in improving business competitiveness and strengthening human capital through directed spending. Nevertheless, government expenditures must be economically sustainable in the long term since high debt levels may have a detrimental effect (Nasir et al., 2021); (Sanusi et al., 2012). To achieve technological progress, solid institutions and governance are critical, whereby in ASEAN's case, there is often a lasting influence of deterministic and historical factors. Until now, government effectiveness has often been shaped by the formative forces of a country's historical past, such as its colonial legacy and institution-building (Acemoglu et al., 2001).

Hypothesis 3: Higher government spending strengthens technological capability.

FDI

Technological progress enabled by FDI requires differentiated considerations. (Samrat and Kumarjit, 2012) found that FDI can supplement the growth momentum in the long run, thanks to the inclusion of technological progress. (Nasir et al., 2021) detected a significant positive effect of FDI on economic growth in Asia Pacific. They also observed that a favorable business environment will increasingly attract investors and make a country more competitive for FDI when technology transfer increases productivity. However, as described above, the transfers might be limited to a narrow range of production processes (Baldwin, 2011) and depend on skilled human capital (Rueda Maurer, 2017).

Hypothesis 4: Higher FDI inflows require an educated, healthy and older population to materialize in higher technological capability.

Trade openness

Trade is beneficial for enhancing a nation's skills base. It strengthens the diffusion of knowledge and technology transfers resulting from the importation of high technology goods (Baldwin et al., 2005); (Barro and Sala-i-Martin, 1995). Open countries have greater access to new technologies and larger markets, allowing them to undertake more specialized production. It also provides them with the competitive pressure necessary to increase efficiency and productivity (Radelet et al., 2001). Furthermore, exports can positively contribute to prosperity from the supply side by exploiting economies of scale or promoting the diffusion of technical knowledge (Grossman and Helpman, 1991). However, the connection between trade openness and prosperity is seldom linear. Beneficial effects do not appear automatically, but only once a country has reached a specific development threshold and appropriate, broader economic policies accompany trade openness. Indeed, failure to achieve growth may not be due to protectionism but existing market failures or deficiencies in human capital, the financial system, innovation, or research capabilities (Zahanogo, 2016).

Hypothesis 5: A greater trade openness is associated with higher technological capability.

Technological capabilities

To overcome the previously identified 4IR risks of premature deindustrialization and technology lending and embrace disruptive growth, a country's level of technological capability is paramount and helps an economy to become more efficient and productive. Therefore, we use export and patent data to determine levels of technological capability of emerging clusters.

Sophistication of exports

Lall's categories of technological progress propose a categorization for sophistication of manufactured goods. It uses export data from the Standard International Trade Classification (SITC) at the three-digit level and groups them according to low-, medium- and high technology products (see Table 2). Exports with a high technological intensity reflect advanced skills, technological endowments, and capabilities in these countries. This creates a framework for a more rapid transfer and diffusion of new technology. At the other end of the scale are the low technology products that are largely labor intensive and undifferentiated, competing only on price and low-waged labor. These tend to have a limited learning potential and create less spillovers to other activities. By contrast, in the middle are countries relying on existing technologies with relatively weak improvements in quality, but with advanced skill needs and lengthy learning periods. Many have mass assembly or production plants with extensive supplier networks being of particular importance (Lall, 2000); (Lall et al., 2005).

Patents

Patents are an important indicator of innovative activity as they represent technological change and development. They constitute an exclusive right to exploit an invention over a limited time-period within the country where the application is made. They are granted for inventions that are novel and often have an industrial application. Inventors are motivated by the prospect of monopoly rents that can be captured when a successful innovation is patented (Aghion and Howitt, 1992). Due to the control over technology, the patent holder can set a higher-than-competitive price for the corresponding good or service that allows the recovery of innovation costs (OECD 2004). Patents influence innovation through cost-saving technologies and new product developments, which in turn promote economic growth (Ragupathi and Ragupathi, 2017).

Methodology

Cluster analysis

We used dynamic pattern synthesis – a mixed-method developed by (Haynes, 2018) – to analyze dynamic social and economic change over

Table 2
Technological sophistication categories of exports (Lall, 2000); (Lall et al., 2005).[1]

Low technology products	Medium technology products	High technology products
Labor-intensive and resource-intensive manufactured goods (LT1)	Automotive (MT1)	Electronics and electrical products (HT1)
Low-skill and technology-intensive manufactured goods (LT2)	Chemicals and basic metal industrial products (MT2)	Other high technology products (HT2)
	Engineering products (MT3)	

time within ASEAN. This method combines the strengths of cluster analysis as well as qualitative comparative analysis (QCA) and results in groupings of ASEAN countries whose manufacturing resources display similar patterns. Dynamic pattern synthesis operates in the complex domain, where disruptions to cause and effect are more likely. Nevertheless, this method points to specific characteristics by identifying patterns and examining how consistent and replicable they are over time. The approach has the advantage that we can examine manufacturing resource combinations and deviating paths within and between clusters for patterns that determine the readiness of ASEAN member countries with similar characteristics.

We applied a hierarchical method for the cluster analysis, as we made no prior assumption or specification of the number of clusters beforehand. Specifically, we computed dendrograms as the most common tool for visualizing clusters. Euclidian distances based on multiple indicators can be disproportionately influenced by variables with larger values. For this reason, we calculated z-scores for all variables before embarking on the analysis. Here, z equals the data observation minus the sample mean average and is then divided by the sample standard deviation. Additionally, we used the Ward linkage method, which merges clusters based on the smallest possible increase in the error sum of squares calculations. This method isolates the optimal number of descriptive clusters early in the calculation process.

We repeated the procedure for the 14 years in our data range with the same cases and observed variable measures to identify the movement of countries. With this approach, we gained a detailed overview of cluster membership dynamics over time. We then interpreted the resulting dendrograms by analyzing the closest connections between countries to make informed qualitative decisions about the most "real" clusters, which we then considered to be outcome findings.

We then conducted a crisp set quantitative comparative analysis (csQCA) to investigate how well these initial results qualified as clusters. This is a case-based method that focuses on the comparison of cases instead of aggregated variable scores. We reduced the variables used to define the clusters to binary levels – either above or below threshold – which, in this case, is the mean. We allocated zero (0) to below mean values and the number one (1) to above mean values, respectively. We used the crisp set allocation to generate a "truth table" to present the binary scores for each case. We then analyzed the truth table to compare the prime implicant variables, which specify how well clusters are validated and which variables may diverge. In order to extend the scores to all years considered, we created a "longitudinal truth table" which displays the overall percentage value in which a country was above the mean (see Table 5).

After forming the linear cluster modeling, we used an analysis of variance (ANOVA) with the inclusion of an η-effect test to measure the extent to which individual variables (now acting independently in bivariate analysis) can confirm substantive mean average differences in the clusters. Here, $\eta^2 = 1$ represents a perfect linear relationship between the variable and cluster membership, while $\eta^2 = 0$ does not affect cluster membership (Haynes and Haynes, 2016).

Dataset

To conduct the cluster analysis, we used longitudinal panel data drawing from World Bank, IMF, and UNDP databases.

Human Capital:

- Life expectancy at birth (UNDP 2021)
- Mean years of schooling, 25-year-olds and older (UNDP 2021)
- Age dependency ratio by the percentage of the working-age population (UNDP 2021)

Gross Capital Formation:

- Gross capital formation as a percentage of GDP (IMF April 2021)

Government Expenditure:

- General government total expenditure as a percentage of GDP (IMF April 2021)

FDI:

- Foreign direct investment (net inflows) as a percentage of GDP (World Bank 2021)

Trade Openness:

- Export Orientation (current account balance) as a percentage of GDP (World Bank 2021)
- Trade (sum of exports and imports) as a percentage of GDP (World Bank 2021)

We normalize most variables as percentage of GDP to account for differences in size of the economy, which make ASEAN country growth between 2006 and 2019 comparable. In addition, we use linear interpolation by calculating the average of adjoining data items to estimate the approximate value of eight missing data points.[2]

Technological capabilities

Technological sophistication of exports

The sophistication of exports was determined by firstly matching the SITC product codes of each ASEAN country to the high-, medium- or low technology category as displayed in Appendix A (Table A.1). The total sum of exports in the year 2019 was then calculated by adding the total product value of exports for each category. The results were then displayed as a percentage of total exports in the specific country and period. The categorization represents a good assessment of a country's technological sophistication. A limiting factor is a possible influence of the level of technological development of the supply chain to which the country belongs.

Patents

Patent data of resident applications per million inhabitants were analyzed between the years 2006 and 2019 to reflect the timeframe of the cluster analysis. This specific measure was chosen, as it excludes applications from foreigners and accounts for differences in population size between ASEAN countries. Clusters are assigned to the high-, medium- or low technology category according to their countries' mean scores of applications. The advantage of using patent data is that it is publicly available in online databases and even though patenting practice and the patentability of technology may vary, patents are a good proxy to determine innovative activities in a country.

[1] Product groups with correspondence to SITC as proposed by Rueda Maurer (2017) are presented in the Appendix A (Table A.1).

[2] Missing trade data: Laos 2017, 2018, 2019; Myanmar 2019; missing gross capital formation data: Myanmar 2006, 2007, 2019; Laos 2019

Dataset

To determine exports as per their technological sophistication per country, we used data drawing from the World Integrated Trade Solutions (WITS) database. To provide the number of patents issued that accounts for differences in inhabitants, we used data normalized by population size from the World Intellectual Property Organization (WIPO) database.

Technological sophistication of exports :

- Gross exports per country to the world SITC Revision 3, 3-digit level (WITS 2021)

Patents :

- Patent resident applications per million population (World Intellectual Property Organization 2021)

Findings

ASEAN country cluster

The results of the cluster analysis are shown in Tables 3 – 7. Table 3 displays the home cluster for each ASEAN country from 2006 to 2019. Outliers, which cannot be attributed to a specific cluster within a year, are shown separately. Cluster stability (Table 4) shows how many times a country was assigned to a specific cluster in the years considered. Most clusters remained relatively stable, apart from Singapore and Brunei, who were outliers more often than being part of a cluster. For this reason, we consider Singapore and Brunei to be niche players, each having unique characteristics and exclude them in the subsequent analysis of patterns. While the city-state of Singapore is the region's financial services and logistics hub, Brunei is almost completely dependent on the exploitation of petroleum and gas.

The analysis produced the three "home" clusters below, with which countries were associated in the majority of years, whereby the second cluster showed the greatest instability.

- Cluster 1: Cambodia, Laos, and Myanmar
- Cluster 2: Indonesia and the Philippines
- Cluster 3: Malaysia, Thailand, and Vietnam

The truth table shows the characteristics of the clusters (see Table 5). It depicts how often a country achieved above-mean scores for each variable, where 100% equals above-mean every year and 0% that a nation was classified as below-mean for the period in question.

To check for stability of our results, we analyzed the economic dynamic over time, and calculated the yearly standard deviation of average between-year percentage changes for all variables (Table 6). The most unstable period was 2008 – 2010, reflecting the turbulence of the global financial crisis. However, from 2012 onwards, a stabilization is visible.

Lastly, we computed the variables, which contribute most to cluster formation. We expanded the η^2 value analysis to account for the longitudinal character of the panel data. Specifically, we compared the number of years in which a variable achieved a specific η^2 value ranging from zero (0) to one (1). The most frequent η^2 brackets and variables are displayed with descending contribution to cluster formation (Table 7). Our findings from this analysis reveal that human capital and trade variables contributed most to cluster formation.

Figures 1 - 8 show 2006 and 2019 levels per cluster and variable.

Countries in Cluster 1 display similar human capital variables with above-average dependency ratios, owing to their young populations and, at the same time, poor health and education levels. Although the values in education increased by 32 percent in Cluster 1, schooling remained 3.7 years lower in 2019 compared to the other clusters (Fig. 2). In terms of life expectancy, countries in Cluster 1 narrowed the gap by

Table 3
Home clusters of ASEAN countries from 2006 – 2019.

	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Cluster 1	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Laos Myanmar Indonesia	Cambodia Laos	Laos Myanmar Indonesia	Cambodia Laos	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Cambodia Laos Myanmar	Laos Myanmar
Cluster 2	Indonesia Philippines	Indonesia Thailand	Indonesia Philippines Thailand	Indonesia Philippines Thailand	Indonesia Vietnam	Indonesia Thailand Vietnam	Cambodia Philippines	Indonesia Philippines Myanmar	Cambodia Philippines	Indonesia Myanmar	Indonesia Philippines	Indonesia Philippines	Indonesia Philippines	Indonesia Philippines
Cluster 3	Malaysia Thailand Vietnam	Malaysia Philippines	Malaysia Brunei	Malaysia Brunei	Malaysia Thailand Philippines	Malaysia Brunei	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam	Malaysia Thailand Vietnam
Cluster 4							Brunei Singapore					Brunei Singapore		Brunei Singapore
Outlier	Brunei Singapore	Brunei Singapore Vietnam	Singapore Vietnam	Singapore Vietnam	Brunei Singapore	Philippines Singapore		Brunei Singapore	Brunei Singapore	Brunei Singapore Philippines	Brunei Singapore		Brunei Singapore	Cambodia

Table 4
Cluster association by country from 2006 – 2019.[3]

Country	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Outlier
Cambodia	11	2			1
Laos	14				
Myanmar	12	2			
Indonesia	2	12			
Philippines		10	2		2
Malaysia			14		
Thailand		4	10		
Vietnam		2	9		3
Brunei			3	3	8
Singapore				3	11

Table 5
Longitudinal truth table from 2006 – 2019.

	Health	Education	Dependency Ratio	Gross Capital Formation	Government Expenditure	FDI	Export Orientation	Trade
Cambodia	0%	0%	100%	0%	36%	100%	0%	50%
Laos	0%	0%	100%	100%	50%	57%	0%	0%
Myanmar	0%	0%	100%	64%	29%	0%	0%	0%
Indonesia	0%	79%	86%	100%	14%	0%	0%	0%
Philippines	0%	93%	100%	0%	7%	0%	36%	0%
Malaysia	100%	93%	7%	0%	100%	0%	100%	93%
Thailand	100%	29%	0%	36%	57%	0%	50%	64%
Vietnam	100%	71%	0%	43%	86%	36%	36%	100%
Brunei	100%	93%	0%	57%	100%	0%	100%	0%
Singapore	100%	93%	0%	50%	0%	100%	100%	100%

Table 6
Standard deviation of average between-year percentage change of variables from 2006 – 2019.

	2006–2007	2007–2008	2008–2009	2009–2010	2010–2011	2011–2012	2012–2013	2013–2014	2014–2015	2015–2016	2016–2017	2017–2018	2018–2019
Average	134	11	546	696	14	359	4	4	7	12	10	5	2

Table 7
Contribution to cluster formation frequency of η^2 value brackets from 2006 – 2019.

η^2	Health	Education	Export Orientation	Dependency Ratio	Trade	FDI	Gross Capital Formation	Government Expenditure
0.9 - 1	4	1	1					
0.8 - 0.9	10	13	10	2				
0.7 - 0.8			2	11				
0.6 - 0.7			1	1				
0.5 - 0.6					5			
0.4 - 0.5					9	3	1	1
0.3 - 0.4						9	3	3
0.2 - 0.3						1	3	1
0 – 0.2							7	9

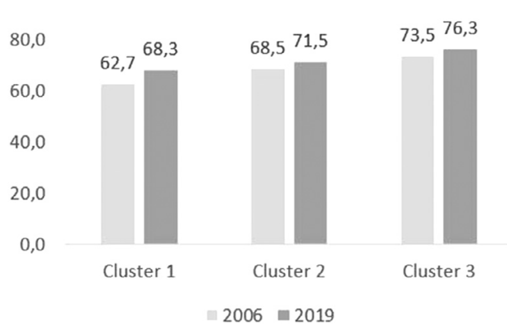

Fig. 1. Life expectancy at birth (years).

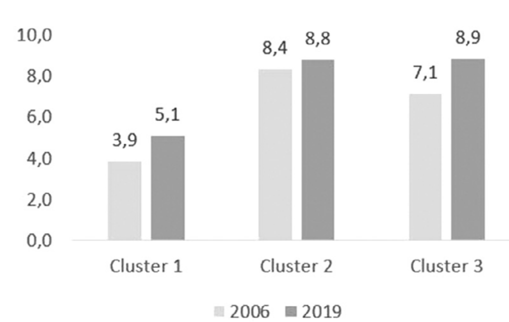

Fig. 2. Mean years of schooling.

increasing this by nine percent between 2006 and 2019 (Fig. 1). Cluster 1 countries experienced the most rapid decrease in dependency ratios (Fig. 3). Gross capital formation of Cluster 1 increased and, at 28.6 percent in 2019, reached the second-highest level, with Cambodia showing lower levels of capital formation (Fig. 4). All the nations in this cluster were in the bottom half concerning government expenditure. A government expenditure increase of 56 percent in Cluster 1 surpassed that of

[3] Countries are displayed in alphabetical order per cluster

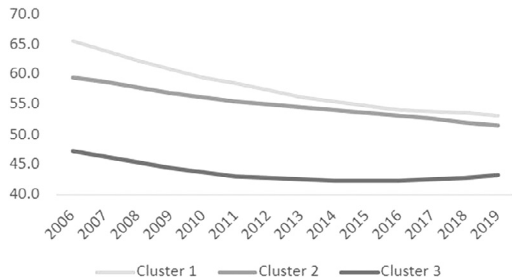

Fig. 3. Dependency ratio (as % of working-age population).

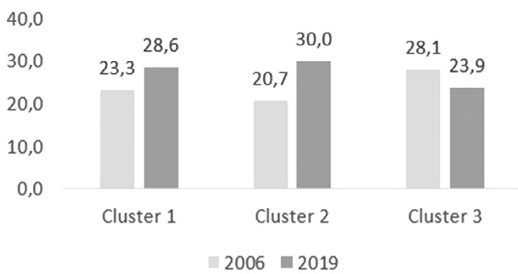

Fig. 4. Gross capital formation (as % of GDP).

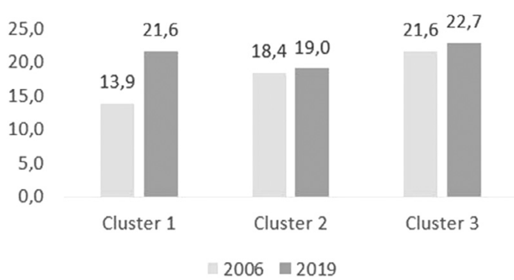

Fig. 5. Government expenditure (as % of GDP).

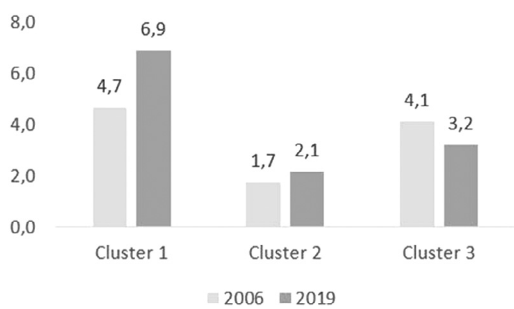

Fig. 6. FDI net inflows (as % of GDP).

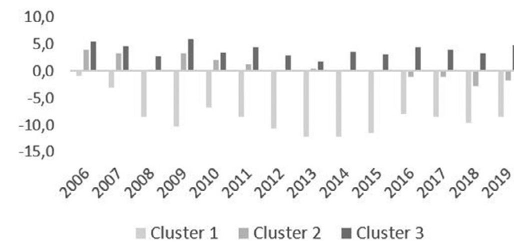

Fig. 7. Export orientation (current account balance as % of GDP).

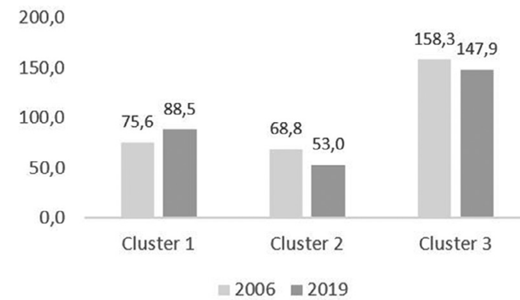

Fig. 8. Trade (sum of exports and imports as % of GDP).

Cluster 2 (Fig. 5). Cluster 1 increased FDI flows by nearly half from 2006 levels, and at nearly seven percent in 2019, it was the most attractive for FDI (Fig. 6). Countries in Cluster 1 sustained, on average, current account deficits – their balances even deteriorated over time – reaching deficits of up to 12 percent. At the same time, Cluster 1 was the only cluster to increase trade, in this case by 17 percent (Figs. 7 & 8). Cambodia had higher figures for trade and FDI flows.

For the Cluster 2 nations – the Philippines and Indonesia – life expectancy at birth was below average. Both countries still have a relatively young population and are in the upper percentile for education performance. In 2019, Clusters 2 and 3 were nearly level. Concerning life expectancy and education, there is a larger gap, as with a similar growth rate, people can expect to live five years less in Cluster 2 than in Cluster 3 (Figs. 1 & 2). The dependency ratios for Clusters 2 and 3 both decreased by 13 percent compared to the 2006 figures as the population grew older (Fig. 3). Gross capital formation in Cluster 2 increased by 45 percent and with 30 percent of GDP was, in 2019, the highest of all clusters (Fig. 4). Indonesia's values for gross capital formation were above average in all years considered, whereas both countries show low government expenditure values compared to their peers. Government expenditure of Cluster 2 changed slightly by 3.5 percent (Fig. 5). Lastly, both countries have inward-looking economies, with constant below-average levels of FDI and trade figures, with the Philippines maintaining a moderately higher current account balance. Countries in Cluster 2 increased their foreign investments from 2006 to 2019 – although at a lower level than Cluster 1 – and remained the weakest by comparison (Fig. 6). Trading figures for Cluster 2 countries decreased by 23 percent between 2006 and 2019. In addition, current accounts turned from initial positive balances to negative in 2016 and had not recovered by 2019 (Figs. 7 & 8).

Cluster 3 has a lower dependency ratio with an older population compared to the other clusters and, at the same time, enjoys higher levels of health and education. Only Thailand underperforms regarding years of schooling. Government expenditure is the highest of the three clusters, and capital formation is primarily low, with Malaysia below average for the entire period. Cluster 3 gross capital formation deteriorated by 15 percent from 2006 to 2019 and reached its lowest level compared to other clusters (Fig. 4). Government expenditure in Cluster 3 rose slightly – by 5.2 percent (Fig. 5). This cluster is the most open in terms of trade; however, except for Vietnam, FDI inflows are weak. FDI flows to countries in Cluster 3 fell by 23 percent between 2006 and 2019 and showed the second-highest overall figure at the end of the period (Fig. 6). These nations preserved current account surpluses in all years, with Vietnam being slightly lower than the others. In Cluster 3, trade decreased over the period, but at almost 148 percent, was still the highest overall in 2019 (Figs. 7 & 8).

Technological capabilities

Technological sophistication of exports

Table 8 depicts the value of exports per technological category in percent of total exports in 2019. The majority of Cluster 1 countries' exports are in labor and resource intensive manufactured goods. From these, only Laos manages to tap into medium technology, which is mainly

Table 8
Export sophistication categories in the year 2019 (in % of total).

		Technological Sophistication						
Cluster	**Country**	**LT1**	**LT2**	**MT1**	**MT2**	**MT3**	**HT1**	**Other**
Cluster 1	Cambodia	85%	6%	3%	n/a	3%	3%	n/a
	Laos	33%	13%	1%	1%	33%	17%	3%
	Myanmar	85%	3%	n/a	3%	7%	2%	n/a
Cluster 2	Indonesia	29%	22%	14%	8%	14%	13%	1%
	Philippines	4%	5%	2%	n/a	16%	70%	3%
Cluster 3	Malaysia	5%	11%	1%	2%	15%	59%	6%
	Thailand	7%	13%	20%	1%	28%	29%	2%
	Vietnam	30%	13%	1%	1%	8%	45%	2%

Table 9
Patent resident applications per million population (total count 2006 – 2019)[4].

		2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Cluster 1	Laos	1													
Cluster 2	Indonesia	1	1	2	2	2	2		3	3	4	4	9	5	11
	Philippines	3	3	2	2	2	2	2	2	3	4	3	3	5	5
Cluster 3	Malaysia	20	25	30	44	44	38	38	41	45	42	36	37	35	34
	Thailand	16	14	14	15	18	14	15	23	15	15	16	14	13	12
	Vietnam	2	3	2	3	3	3	4	5	5	6	6	6	7	7

owed to its exports in telecommunications equipment. In Cluster 2 there is some divergence between the countries, as Indonesia's exports are more diversified with footwear and automobiles playing an important role, whereas the Philippines generate a majority of exports in the high technology sector, mainly in computer and semiconductors. Lastly, in Cluster 3, Malaysia is the most advanced, while Thailand is strong in the medium-tech automobiles sector and Vietnam still has a comparatively large presence in low technology production, namely in textiles and at the same time also shows some activity in the high technology sector.

Patents

ASEAN countries' patent resident applications per million population between the years 2006 and 2019 are shown in Table 9. For Myanmar and Cambodia no data has been reported or was below 1 in most years and Laos has a mean of 0.1 applications therefore Cluster 1 countries' patent applications are negligible. This matches export sophistication data, as the countries are dependent on technology imitation and transfer from abroad rather than creating indigenous innovation. For Cluster 2, patents applications remain at a similar level over the years, Indonesia has a mean of 3.5 and the Philippines of 3 patents per year although Indonesia has shown a stronger performance since 2017, having more than twice as many patents as the Philippines in 2019. As the export sophistication data has shown, Malaysia has a strong presence in the high technology sector, which is also reflected in its comparatively higher number of patents (mean of 36) while Vietnam (mean of 4.5) is behind its peers as the country's upgrading of technology is ongoing. Meanwhile, Thailand's patent applications (mean of 15) have been declining since 2013, which is a negative signal with regards to the development of its technological capabilities.

Considering export sophistication and patent application data combined, the following results per cluster emerge:

- Cluster 1: low technological capability
- Cluster 2: mid-level technological capability
- Cluster 3: high technological capability

[4] Data for Cambodia and Myanmar < 1

Emerging patterns

In Table 10 we reduce the variables resulting from a longitudinal truth table that excludes Singapore and Brunei (see Appendix B, Table B.1) to binary levels – either above or below the mean for all three clusters. We allocated the value "Below" to below mean values and "Above" to above mean values, respectively and matched the clusters to the level of their technological capability. This allows us to analyze the performance of each country individually and to see how well it fits the general pattern of a specific cluster. We will use the patterns to test our hypotheses.

Hypothesis 1: A well-educated, healthy and older population is associated with higher technological capability.

The patterns support the hypothesis in most cases. A healthy, well-educated and older population is favorable for technological capabilities. People that expect to live longer are also more willing to devote time to education. Cluster 1 countries lack the health and education levels that are necessary to develop their own technological capabilities. Cambodia and Laos tend to have younger populations but do not seem able to exploit wage advantages of younger workforces. Cluster 2 countries are positioned in the middle, as they are above average in educational attainment, however behind Cluster 3 in terms of health. Age patterns of Cluster 2 display a mixed picture. Cluster 3 countries clearly show an above-average score in health and education, which is positively associated with its strong performance in export sophistication and patent data.

Hypothesis 2: Higher capital formation is associated with higher technological capability.

Gross capital formation does not show a clear pattern with regards to technological capabilities of the clusters. Specifically, in two countries of the most technologically advanced Cluster 3, capital formation was below average in most years. At the same time, while Cambodia's capital formation is below average, Myanmar and Laos' results are both above mean, despite their weak technological capabilities. The same unclear pattern emerges for Cluster 2.

Hypothesis 3: Higher government spending strengthens technological capability.

Table 10
Cluster patterns in association with level of technological capability from 2006 – 2019.

			Health	Education	Dependency Ratio	Gross Capital Formation	Government Expenditure	FDI	Export Orientation	Trade
Technological Capability	Low	Cambodia	Below	Below	Above	Below	Below	Above	Below	Above
		Laos	Below	Below	Above	Above	Above	Above	Below	Below
		Myanmar	Below	Below	Below	Above	Below	Below	Below	Below
	Mid	Indonesia	Below	Above	Below	Above	Below	Below	Above	Below
		Philippines	Below	Above	Above	Below	Below	Below	Above	Below
	High	Malaysia	Above	Above	Below	Below	Above	Below	Above	Above
		Thailand	Above	Above	Below	Below	Above	Below	Above	Above
		Vietnam	Above	Above	Below	Above	Above	Above	Above	Above

The patterns support the previously stated hypothesis with the exception of Laos. Results suggest that Cluster 3 countries' spending is above its peers, which is beneficial for increasing technological capabilities and may equal higher expenditures in research and development as well as in infrastructure. Moreover, it may point to higher spending in the formal economy on education and social security, which strengthens human capital. More importantly, spending seems to be within sustainable thresholds and in the case of the three countries face similar institutional strength. On the other hand, except for Laos, the mid- and low-ranking cluster countries showed below average government spending in most years. As these countries have large informal economies, they may lack sufficient fiscal revenues to reinvest into their technological development or suffer from weak institutional environments.

Hypothesis 4: Higher FDI inflows require an educated, healthy and older population to materialize in higher technological capability.

FDI does not show a clear pattern with regards to technological capabilities of the clusters. Findings for low technology countries suggest that along with FDI, skilled and healthy human capital is required to build up their capabilities. Two countries in Cluster 1 show high FDI inflows, mainly also due to their cheap labor costs but score lowest in terms of capabilities. As previously mentioned, this may be the result of technology lending. At the same time, evidence looks mixed for countries with more advanced technological levels. For these, FDI is not necessarily a precondition to achieve high technological capabilities with Vietnam as only exception. The advanced countries seem to have managed to take advantage of its human capital to avoid technology lending and instead establish a high technology sector domestically.

Hypothesis 5: A greater trade openness is associated with higher technological capability.

The patterns support the hypothesis in most cases: higher technological capability is associated with both high trade levels and export orientation. Results show that high technological capability countries have current account surpluses as they usually have export-oriented economies and above average trade volumes. While Cluster 2 countries are export-oriented, their trade volumes are below mean. Cluster 1 maintained current account deficits in most years, which suggests countries could not transform their foreign investments into higher exports. Except for Cambodia, Cluster 1 countries' trade volume is below average.

Conclusion

The emergence of automated cyber-physical systems of the 4IR may mean the end of high technology and low skill collaboration and exposes some developing countries in ASEAN to the risk of premature deindustrialization and labor substitution. Countries that have relied heavily on this type of supply chain integration and failed to build their own technological capabilities to absorb labor forces are particularly impacted by the risks. Our analysis shows that the main drivers of cluster formation in ASEAN, namely human capital and trade, also have the highest impact on technological capabilities. As the findings above have highlighted ASEAN is a highly diverse region, whereby its member states should concentrate on these two areas and advance them in accordance with their level of technological development.

Their young population makes Cluster 1 countries attractive destinations for multinationals and manufacturers of low technology products whereby little short-term incentive exists to adjust their economies in light of the 4IR. Due to the weak quality of their human capital, these countries are exposed to technology lending. At the same time, their governments do not seem to be in the position to play an active role in the development of human capital and infrastructure. Ongoing political instability hinders the orientation towards long-term technological and economic development. Despite encouraging signs with regards to capital formation, the number of patent applications does not indicate entrepreneurial induced creative destruction. These countries are therefore the least ready for the 4IR as their technological capability is not strong enough to compensate for the impacts of increasing labor substitution and retreating multinational companies.

The quality of human capital and the extent of capital formation in Cluster 2 is mixed, as governments of the two countries seem to struggle to strengthen both. The countries engage at times in unproductive trade and export activities. While they can both rely on the advantage of a large domestic consumer market, there exist weaknesses in attracting foreign investors. Furthermore, the remoteness of many regions in these archipelagic nations and the lack of infrastructure could pose a problem towards spreading its technological capabilities. Despite some capital formation, patent application numbers are too low to indicate entrepreneurial activity and induced creative destruction. Whether these two countries are ready for the 4IR is uncertain, strengthening of technological capabilities requires more decisive actions and outward engagement.

Countries of Cluster 3 benefit from above-average human capital, trade activities and government support. This cluster seems to be the readiest in light of the 4IR. However, creative destruction is weak. The countries are building capital and attracting investors at various and even declining levels. With wages expected to rise, Cluster 3 will increasingly compete with other high technology countries and will have to implement the new 4IR technology comparatively faster. Therefore, the cluster's favorable human capital is not yet fully exploited - with weaknesses in infrastructure and the availability of foreign technology - the basis to unfold its potential.

Our results are in line with previous empirical evidence. Human capital is key in facilitating technology absorption. The three human capital variables are interrelated, with education playing a central role in deriving benefits from available technology. Educated citizens have a skill base that they can link to new knowledge, thereby continuously building expertise. Healthy populations with higher life expectancy have more incentives to invest in education. Older populations benefit from building on previously acquired knowledge and can enhance it by engaging in continuing education. The findings of our analysis also support the argument that trade facilitates not only the access to technological knowledge but also provides incentives for technological advancement in view of the global competition to attract investments. The two trade variables have been found to be interrelated. Exporting companies have higher incentives to engage in trade related activities to capitalize on their investments and at the same time, they are more dependent on raw material imports for production. This points to the importance of higher value-added production capabilities. Therefore, given some pattern evidence we propose as way forward to test for an interrelation of trade with human capital variables in promoting technological capability.

Our results suggesting that government spending promotes technological capability are also in line with previous empirical evidence. We propose channelling spending into promoting the quality of human capital and export orientation. However, spending needs to be accompanied by economic policies and supported by strong institutions to unfold its potential. In this respect, ASEAN could consider assuming a more active role in supporting its members to benefit from transactional links. Its institutions will play an essential role as a regional organization in enhancing human capital and free trade to advance the region's technological sophistication and interconnectedness.

While ASEAN is not expected to assume more executive power, its main objective should be to oversee the various activities and initiatives related to the 4IR, ensuring they are well executed and that stakeholders are fully informed. In addition, ASEAN should focus on the need for common standards since the 4IR is expected to blur physical boundaries. Issues such as the free flow of data across borders, including data security, fiscal policy, cloud services, and education, can no longer be resolved within the nation-state itself. Therefore, a certain degree of standardization may be required to reduce trade barriers among members.

Considerations of FDI paired with high quality human capital as enabler of technological development have not yielded clear answers. The results from the shifted focus to individuals and entrepreneurs as adapters of new technologies and drivers for change were also unclear. We found little evidence for creative destruction driving growth by rendering an economy more efficient and productive. Given the still significant importance of the informal economy in Southeast Asia, especially in Cluster 1 countries, it might be worthwhile examining to what extent creative destruction expresses itself differently than in advanced countries.

During its existence, ASEAN and its member states have overcome various challenges, ranging from the impact of geopolitical conflicts to financial crises and the current pandemic. As the results have shown, the 4IR will bring unprecedented changes and present both risks and opportunities. Countries that are aware of the risk and prepare themselves to embrace the opportunity of technological advancement are ready for the upcoming 4IR. ASEAN will have the opportunity to become a model for other developing countries to follow. However, in an increasingly interconnected global economy, it will be functioning systems that will succeed regardless of physical borders. In analyzing the country clusters, it became clear that there are still large divides, particularly between the least developed countries in Cluster 1 and those in Cluster 3. Narrowing this gap will be critical to establishing new business opportunities and creating a more equitable and prosperous ASEAN that will benefit all members. To prepare the region for the 4IR, there is no one generic formula; rather, the unique characteristics of each cluster must be recognized. Ensuring ASEAN's success for decades to come will therefore depend on a concerted effort to improve human capital, trade openness, and governance among member states, as well as enhanced regional cooperation.

Declaration of Competing Interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.aglobe.2021.100021.

Appendix A. SITC Codes

Table A.1. Three-digit product groups SITC Rev. 3, by level of manufacturing (Rueda Maurer, 2017).

LT1	LT2	MT1	MT2	MT3	HT1	HT2
611	642	781	653	711	716	712
612	665	782	671	713	718	792
613	666	783	672	714	751	871
651	673	784	679	721	752	874
652	674	785	786	722	759	881
654	675		791	723	761	
655	676		882	724	764	
656	677		883	725	771	
657	678			726	774	
658	691			727	776	
659	692			728	778	
831	693			731		
841	694			733		
842	695			735		
843	696			737		
844	697			741		
845	699			742		
846	811			743		
848	821			744		
851	892			745		
	893			746		
	894			747		
	895			748		
	896			749		
	897			762		
	898			763		
	899			772		
				773		
				775		
				793		
				812		
				813		
				872		
				873		
				884		
				885		
				891		

Appendix B. Longitudinal Truth Table

Table B.1. Longitudinal truth table from 2006 – 2019 (excl. Singapore and Brunei).

	Health	Education	Dependency Ratio	Gross Capital Formation	Government Expenditure	FDI	Export Orientation	Trade
Cambodia	0%	0%	100%	0%	43%	100%	0%	100%
Laos	0%	0%	100%	100%	57%	79%	0%	0%
Myanmar	0%	0%	36%	64%	43%	21%	36%	0%
Indonesia	0%	93%	0%	93%	21%	0%	79%	0%
Philippines	43%	93%	100%	0%	14%	0%	100%	0%
Malaysia	100%	93%	0%	0%	100%	14%	100%	100%
Thailand	100%	93%	0%	43%	93%	7%	93%	100%
Vietnam	100%	93%	0%	57%	93%	93%	64%	100%

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