RESEARCH ARTICLE
https://doi.org/10.17059/ekon.reg.2022-1-4
UDC: 327.5; 33.06.1–6; 339.5
JEL Classification: F12; F14; F15; O32

Jongkers Tampubolon [a)], *Tongam Sihol Nababan* [b)]
[a, b)] HKBP Nommensen University, Medan, Indonesia
[a)] http://orcid.org/0000-0002-7142-0606, e-mail: jtampubolon@yahoo.com
[b)] https://orcid.org/0000-0001-6455-1459

ASEAN's Factory Economy in the Fourth Industrial Revolution Era[1]

East Asia is the most dynamic region showing high economic growth in the last decades. This is attributed to the "Factory Asia", which refers to regional fragmentation of production. In this case, technologically advanced countries, also called headquarter economies, hollow out the most labour-intensive production stage to the ASEAN countries and make it a "factory economy" producing parts and components. Technological developments in the fourth industrial revolution era have introduced labour-saving technologies in the manufacturing sector. As a result, low wages have become a less important determinant of competitiveness, which is predicted to end "factory Asia." This study examines whether the adoption of Industry 4.0 in manufacturing is detrimental to the factory economy. It investigates intra-ASEAN regional relations and their relationship with headquarter economies, including the USA, Japan, China, and Korea (ASEAN + 1). Utilising the Regional Trade Introversion Index (RTII) analysis tool, the study examines the interdependency between the ASEAN countries and the headquarter economies. The vertical intra-industry trade approach was used to assess the quality of ASEAN's exports to the headquarter economies. The results showed that ASEAN's factory economy was not disrupted by the adoption of Industry 4.0 in the manufacturing sector. With a high intra-industry trade index and the positive intra-ASEAN RTII, the ASEAN trade block strengthens. Exports of higher quality products from ASEAN countries to the headquarter economies, especially China and Korea, have consistently increased. Furthermore, geography is important in network production fragmentation and there is a differentiation among the headquarters and the factory economy.

Keywords: regional integration, regional fragmentation of production, factory Asia, ASEAN's manufacturing, Grubel–Lloyd index, vertical intra-industry trade, regional trade introversion index, quality in exports, 4th industrial revolution, industry 4.0

For citation: Tampubolon, J. & Nababan, T. S. (2022). ASEAN's Factory Economy in the Fourth Industrial Revolution Era. Ekonomika regiona [Economy of regions], 18(1), 49-63, https://doi.org/10.17059/ekon.reg.2022-1-4.

ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

Й. Тампуболон [а)]***, Т. С. Набабан*** [б)]
[а, б)] Университет Nommensen HKBP, Медан, Индонезия
[а)] http://orcid.org/0000-0002-7142-0606, e-mail: jtampubolon@yahoo.com
[б)] https://orcid.org/0000-0001-6455-1459

Экономика «азиатских производств» в странах АСЕАН в эпоху четвертой промышленной революции

В последние десятилетия динамично развивающиеся страны Восточной Азии демонстрируют высокие темпы экономического роста благодаря феномену «Factory Asia» (азиатское производство), другими словами, региональной фрагментации производства. В данном случае компании с головными офисами в технологически развитых странах размещают наиболее трудоемкое производство деталей и компонентов в странах Ассоциации государств Юго-Восточной Азии (АСЕАН). Внедрение трудосберегающих технологий в производственный сектор в эпоху четвертой промышленной революции привело к тому, что низкая заработная плата уже не является определяющим фактором конкурентоспособности. По прогнозам, это может привести к закрытию «азиатских производств». Цель настоящей статьи — определить, наносит ли внедрение Индустрии 4.0 ущерб экономике стран, где размещены «азиатские производства». С помощью индекса интроверсии региональной торговли проанализированы как региональные отношения внутри АСЕАН, так и взаимоотношения между государствами — членами и США, Японией, Китаем и Кореей (АСЕАН + 1). Для оценки качества экспорта стран АСЕАН в страны, в которых располагаются головные офисы компаний, применен анализ вертикально интегрированных межотраслевых корпораций. Результаты исследования показали, что Индустрия 4.0 не оказала негативного влияния на экономику стран АСЕАН. Торговый блок АСЕАН укрепил свои позиции благодаря высокому показателю внутриотраслевой торговли и положительному индексу интроверсии региональной торговли. Экспорт продукции более высокого качества из стран АСЕАН в развитые страны, особенно в Китай и Корею, постоянно увеличивается. Кроме того, на фрагментацию сетевого производства также оказывают влияние географический аспект и экономические различия между странами.

Ключевые слова: региональная интеграция, региональная фрагментация производства, азиатское производство, производство стрран АСЕАН, индекс Грубеля — Ллойда, вертикальные межотраслевые компании, индекс интроверсии региональной торговли, качество экспорта, четвертая промышленная революция, индустрия 4.0

Для цитирования: Тампуболон, Й., Набабан, Т. С. Экономика «азиатских производств» стран АСЕАН в эпоху четвертой промышленной революции // Экономика региона. 2022. Т. 18, вып. 1. С. 49-63. https://doi.org/10.17059/ekon.reg.2022-1-4.

Introduction

The transition from the 20th to the 21st century is manifested by two major forces, including technological advancements and globalisation, which has brought significant changes in people's lives in various ways. Globalisation is influenced by technological advances, especially in communication (Stiglitz, 2007; Shapiro, 2008; Friedman, 2000; Friedman, 2007; Brynjolfsson, McAfee, 2014; Schwab, 2016). To strengthen the competitiveness, Germany introduced an initiative called "Industrie 4.0" at the Hannover Fair in March 2011, which became a global label termed "Industry 4.0"[1]. In June 2011, the USA established an advanced manufacturing partnership, and was subsequently followed by the UK in December 2011, Italy 2012, France 2013, Sweden 2013, Netherlands 2014, and Spain 2015. Although Japan did not specifically emphasise a reform, this aspect was included in "The 5th Science and Technology Basic Plan" in 2015 (Liao et. al, 2018; Pozdnyakova et. al, 2019).

The implementation of Industry 4.0 was believed to bring the fourth industrial revolution, which is indicated by major transformations in three aspects (Schwab, 2006). The first one involves significant changes across all industries, marked by the emergence of new business models, disruption in the current models, and restructuring in the systems of production, consumption, transportation, and delivery of goods. The second

[1] Kagermann, H., Anderl, R., Gausemeier, J., Schuh, G. & Wahlster, W (2016). Industrie 4.0 in a Global Context — Strategies for Cooperating with International Partners. Acatec Study. Retrieved from: https://www.acatech.de/publikation/industrie-4–0-im-globalen-kontext-strategien-der-zusammenarbeit-mit-internationalen-partnern/ (Date of access: 17.05.2019).

one is the paradigm shifts between the communities based on how they work, communicate, obtain information, and enjoy entertainment. The last one involves several sectors, including education, health care, and transportation experience, changes in behaviour, production system, and consumption due to the adoption of the latest technologies.

Several challenges emerged, specifically on supply, working atmosphere, and production, which potentially brings either negative or positive impacts (Brynjolfsson, McAfee, 2014; Schwab, 2016; Liao et. al, 2018; Liu, 2017; Hallward-Driemeier, Nayyar, 2018; Bogoviz et. al, 2019). Various sectors experienced significant impacts, including electronics, computers, and optical instruments, electrical machinery and equipment, and transportation tools. These sectors are the primary sources of economic growth in East Asia, with the Association of Southeast Asian Nations (ASEAN) countries as significant beneficiaries. It is characterised by the regional fragmentation of production, also known as the "factory economy." An increase in the use of automation and robotics in the industry 4.0 era subsequently threatens production fragmentation because of technological applications in "the headquarter economy" such as Japan, China, USA, and Korea. This tends to reverse "hollowing out"/offshore into nations with low wages to re-shore a process that the Asian Development Bank[1] predicted to be the end of the factory economy.

This study examines (1) the development of exports in the ASEAN manufacturing sectors, specifically electrical, mechanical machinery, and vehicle/transportation, which are considered the mainstay of ASEAN's exports in the scheme of factory economy; (2) the interdependency of ASEAN countries and the headquarter economy in a regional trading block; (3) the vertical intra-industry trade with high quality of ASEAN's exports to the headquarter economies.

Literature Review

The history of human life and civilization has passed through two revolutions, particularly agricultural (about 10,000 years ago) and the industrial, with radical and abrupt changes. The invention of the steam engine triggered the industrial revolution by James Watt in 1763–1775, which was applied in mechanical production (Brynjolfsson, McAfee, 2014; Schwab, 2016). This invention was termed as a general technology purpose (GTP). It was economically significant because it interrupted and accelerated the typical march of economic progress, and subsequently affected various sectors (Brynjolfsson, McAfee, 2014). The industrial revolution is defined as the sum of several nearly simultaneous developments in mechanical engineering, chemistry, metallurgy, and other disciplines, which inhibit the sudden, sharp, and sustained leap in human progress.

The unanimous views on the stages in manufacturing evolution were divided into four industrial revolutions (Schwab, 2016; Baldassarre et. al, 2017; Pozdnyakova et. al, 2019), encompassing the first industrial revolution (1780–1840), which entailed the introduction of machines into production. It was achieved primarily by factories through machines powered by water, steam, and heavy manpower. The purpose was to promote agriculture and textile industries, the backbone of the British economy. The second industrial revolution (1870–1944) involved introducing mass manufacturing and division of labour supported by electrification and innovation in chemistry. The third revolution (1950–1970) is well known as the information age, paraded as the direct result of massive computer development, information, and communication technology (ICT). The use of computers and ICT increased complexity in production processes through the enhancement of automation. The fourth revolution occurred around the year 2000 with the computerisation of manufacturing processes up to a new level by introducing customised and flexible mass production technologies. The use of advanced ICT enables factories to connect physical and digital systems. Importantly, the use of intelligent machines enables the system to communicate with each other and people. Therefore, the introduction of self-optimisation, self-cognition, and self-customisation into industries enables manufacturers to communicate with computers rather than only operate them. The most critical difference in the transition from the previous revolution is the elimination of humans from production processes, turning them from socio-technical into full technical systems. Conversely, the entire production processes are formed without human participation (Pozdnyakova et. al, 2019).

The main components of Industry 4.0 include (1) Cyber-Physical System (CPS), (2) Internet of Things (IoT), (3) Internet of Service (IoS), and (4) Smart Factory (Hermann et. al, 2015). These components emphasise the central function of ma-

[1] Asian Development Bank (2017). ASEAN 4.0: What does the Fourth Industrial Revolution Mean for Regional Economic Integration? Asian Development Bank White Paper. Retrieved from: https://www.adb.org/publications/asean-fourth-industrial-revolution-regional-economic-integration (Date of access: 11.06.2019).

chines. The difference with the previous revolution was the ability of machines to communicate with others (IoT), people (Internet of People/IoP), with each other, and with the manufacturers to create a cyber-physical production system (CPPS)[1]. As a result, there is an integration between the real and virtual worlds, enabling machines to collect live data, analyse them, and make decisions, making the processes decentralised, self-organised, and flexible (Bartodziej, 2017).

CPS is the integration among computation and physical processes, embedding computers with network monitors and controlling the physical processes, usually with feedback loops, where the physical processes affect computation, and vice versa. Currently, the CPS has been developed up to the third generation. The first generation included identifying technologies, such as RFID tags (radio frequency identification), which allow unique recognition. The second generation was equipped with sensors and actuators, though with a limited range of functions. The third generation entails data storage and analysis, which is network compatible and fortified with multiple sensors and actuators. IoT can be seen as cooperation of CPS with one another through a unique addressing scheme, which allows 'things' and 'objects' (such as RFID, sensors, actuators, and mobile phones), to interact with each other and collaborate with neighbouring 'smart' components for common goals. Therefore, a smart factory is a system that communicates through IoT to assist people and machines execute personalised tasks (Hermann et. al, 2015). IoT automates production, as well as communicates and shares information to optimise the entire value chain (Hallward-Driemeier, Nayyar, 2018).

Industry 4.0 is powered by nine foundational technological advancements[2], which include big data and analytics, autonomous robots, simulations (including 3-D replication of products, materials, and production processes), horizontal and vertical system integrations, industrial IoT, cybersecurity, cloud computing, augmented reality, and additive manufacturing (consisting of 3-D printing, which is used mostly in prototyping and production of individual components). To show the broadness of this revolution in comparison with transformation, Schwab (2016) detailed its tremendous technological breakthrough, covering a wide range of fields, such as artificial intelligence (AI), robotics, IoT, autonomous vehicles, 3-D printing, nanotechnology, biotechnology, material science, energy storage, and quantum computing. Therefore, the concept involves direct manufacturing in a company and the whole value chain from suppliers to end customers and all enterprise business functions and services (Rojko, 2017). They are based on new business models and means of collaborating with long-term intentions of laying novel foundations for the future.

The technological revolution of ICT in the third industrial revolution led to new developments in production management, which is called global fragmentation. It enables more countries to participate in manufacturing sectors. This pattern is advancing effectively in East Asia, which has made Asia a "factory economy" or "factory Asia". The factory Asia refers to a model of regional production networks connecting factories in different Asian economies to produce parts and components to be assembled with final products shipped mainly to the advanced economies. These networks form parts of regional and global value chains[3]. Practically, it is the offshoring labour-intensive production stages of an advanced nation (i. e., Japan) to those in East Asia[4] through fragmentation of production blocks (Baldwin, Forslid, 2014; Kimura, Obashi, 2011). This practice was exemplified by assembling a disk-driver in Thailand, an affiliate of a Japanese company. The product used disks from the USA, Japan, and Malaysia, and filter cap from Hong Kong, while several parts were imported from numerous countries, including the USA, Mexico, Japan, China, Hong Kong, Taiwan, Malaysia, the Philippines, Singapore, and Indonesia. Hence, production networks involve dozens of countries. Similarly, in case a laptop comprises a motherboard, central processing unit (CPU), hard drive, random-access memory (RAM), graphic system, chipset, and battery, then its production creates at least seven networks, each involving dozens of countries (Baldwin, 2008). A similar case applies to the automotive industry. For instance, Toyota Motors had set up

[1] Luenendonk, M. (2017). Industry 4.0: Definition, Design Principles, Challenges, and the Future of Employment. Retrieved from: http://www.cleverism.com/industry-4–0 (Date of access: 31.05.2019).

[2] Ruessman, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J. Engel, P. & Harnisch, M. (2015). Industry 4.0 — The Future of Productivity and Growth in Manufacturing Industries. Boston Consulting Group. Retrieved from: http://www.zvw.de/media.media.72e472fb-1698–4a15–8858–344351c8902f.original.pdf (Date of access: 17.05.2019).

[3] Byung-il, C. & Rhee, C. (2014). Future of Factory Asia. ADB and KERI. Retrieved from: https://www.adb.org/publications/future-factory-asia (Date of access: 14.08.2019).

[4] Baldwin, R. (2006). Globalization: The Great Unbundling(s). Economic Council of Finland. Retrieved from: repository.graduateinstitute.ch/record/295612/files/Baldwin_06–09–20.pdf (Date of access: 20.07.2019).

a regional structure of activities, with a regional headquarter situated in Singapore. Assemblies occur in Indonesia, Philippines, Malaysia, Vietnam, and Thailand, and part supplies in Malaysia, the Philippines, and two affiliates in Thailand (Bernardino, 2004; Baldwin, Lopez-Gonzalez, 2015).

The regional fragmentation of production in the headquarter and factory economy patterns is today's global phenomenon. This network is marked by regional blocks, also termed Factory North America with the USA as headquarter, Factory Europe with Germany as headquarter, and Factory Asia (Baldwin, Lopez-Gonzalez, 2015; Ando, Kimura, 2003), which seems to be one of the most successful networks, due to the emerge of four new industrialised economies (NIEs) (i. e., Korea, Taiwan, Hong Kong, and Singapore) with ASEAN countries as the hubs for trade in electrical machinery. Factory Asia has generated high level of growth (i. e., above 6 % annually), lasting for 30 years.

Factory Asia was started by hollowing out of the Japanese economy, followed by the division of East Asia into strengthened economic workshops, as Taiwan, Korea, Singapore, and Hong Kong experienced the same strategy, following the lead of Japan in off-shoring the most labour-intensive production stages to the East Asian economies, with a comparative advantage in tasks (i. e. having low-wages) become more compensated for low labour productivity (Fukao et. al, 2016). However, the development of robotics, digitalisation, 3-D printing, and artificial intelligence technology, introduced by Industry 4.0 tends to be cheaper (Schwab, 2016), and this is bound to continuously be inexpensive, following the Moore's Law which stated that with the same dollar value, the amount of integrated circuit power of computer has double each consecutive year; while labour costs tend to increase[1]. Asian Development Bank[2] estimated the end of traditional factory Asia, which entails the re-shoring of production in many industries back to countries with high labour rates, subsequently reduces the attractiveness of foreign investment in the ASEAN manufacturing industries. Furthermore, re-shoring is not a theoretical issue as it was shown in the return of Philips Shavers in the Netherlands[3], Adidas Shoes in Germany[4] and a re-shoring phenomenon in Italy (Talamo, Sabatino, 2018).

Methodology

There are three approaches to assessing any trading-block's significance in trade integration, which is developmental to the previous indices. This includes intensity indicator, homogenous intensity, and introversion index. These indicators are used to measure the bias that an economy or a region has toward partners. In its simplest form, the intra-regional trade intensity index of the region is equal to the ratio between the intra-regional trade and the region's share in world trade (Kojima, 1964). Using the symbols used by Hamanaka (2012; 2015), ASEAN regional intensity is formulated as follows:

$$\textit{ASEAN intraregional intensity} = (T_{ii} / T_i)/(T_i / T_w), \quad (1)$$

$$\textit{ASEAN intensity toward partner}_j = (T_{ij} / T_i)/(T_j / T_w), \quad (2)$$

where, T_w — total world exports plus imports; T_i — total exports of ASEAN to the world plus total imports of ASEAN from the world; T_j — total exports of partner *j* (USA, Japan, China, or Korea, respectively) to the world plus total imports of partner *j* from the world; T_{ii} — ASEAN exports to ASEAN plus ASEAN imports from ASEAN; T_{ij} — ASEAN exports to partner *j* plus exports of partner *j* to ASEAN plus ASEAN imports from partner *j* plus imports of partner *j* from ASEAN.

The intensity indicator sets the world average as the benchmark for comparison. However, this raises a "giant problem", where the large economy or region affects the benchmark (Hamanaka, 2015). Also, there is a problem of "range variability," where the upper limit of the intensity toward partners is high when small traders and vice versa. The homogenous index of intra-regional trade intensity is an alternative solution to the giant problem and range variability by replacing the intra-regional trade index's denominator, substi-

[1] Hammes, T. X. (2018). Technological Change and the Fourth Industrial Revolution. Retrieved from: https://www.hoover.org/research/beyond-disruption-technologys-challenge-governance (Date of access: 12.11.2019).

[2] Asian Development Bank. (2017). ASEAN 4.0: What does the Fourth Industrial Revolution Mean for Regional Economic Integration? Asian Development Bank White Paper. Retrieved from: https://www.adb.org/publications/asean-fourth-industrial-revolution-regional-economic-integration (Date of access: 11.06.2019).

[3] Bloomberg. (2012, January 19). China No Match for Dutch Plants as Phillips Shavers Come Home. Bloomberg Technology. Retrieved from: http://www.bloomberg.com/news/articles/2012–01–19/china-no-match-for-dutch-plants-as-philips-shavers-come-home (Date of access: 11.06.2019).

[4] Financial Times. (2016, June 8). Robot Revolution Helps Adidas Bring Shoemaking Back to Germany. Retrieved from: https://www.ft.com/content/7eaffc5a-289c-11e6–8b18–91555f2f4fde (Date of access: 11.06.2019).

tuting its weight in the trade with the rest of the world. This is equal to zero in the limiting case of no extra-regional trade for weight in world trade as formulated in equations (3) and (4) (Iapadre, 2004):

$$\textit{ASEAN intraregional homogenous intensity } (HI_i) = (T_{ii} / T_i) / (To_i / To) \quad (3)$$

$$\textit{ASEAN extraregional homogenous intensity } (HE_i) = (1 - T_{ii} / T_i) / (1 - To_i / To) \quad (4)$$

where, To — total exports of the world excluding ASEAN plus imports of the world excluding ASEAN; To_i — exports of the world excluding ASEAN (rest of the world) to ASEAN plus imports of the world excluding ASEAN (rest of the world) from ASEAN.

In the homogenous intensity, the range below the neutral is usually much smaller than the range above the threshold. Also, the range goes from zero (no intra-regional trade) to infinity (no extra-regional trade), independent of the region's size ("range asymmetry" problem according to Hamanaka (2015)). The bias toward partners and the world, excluding partners, can move in the same direction. This is called the "dynamic ambiguity" problem.

The introversion index solves both range asymmetry and co-movement problems technically and numerically (Iapadre, 2004; Hamanaka, 2015). The Regional Trade Introversion Index (*RTII*) is formulated, as shown below.

$$RTII = (HI_i - HE_i) / (HI_i + HE_i), \quad (5)$$

where HI_i and HE_i have been defined in equations (3) and (4).

The Regional Trade Introversion Index is the most suitable guide for measuring trade interdependence (Hamanaka, 2012). It considers not only internal but also the external bias of trade. The introversion index assesses the internal bias of trade concerning external bias (relative regional bias of trade). If the indicator of introversion is equal to zero, then the region's trade is geographically neutral. In case it is greater than zero, the region's trade has an intraregional bias. However, in case it is less than zero, the trade has an extra-regional bias. Sorhun (2014) used this approach in analysing the potential economic effects of a further Free Trade Area (FTA) founded within the Shanghai Cooperation Organisation (SCO). The same method was applied to measure the character of trade integration in Africa (Bouet et. al, 2017). In this study, *RTII* is used to assess ASEAN's regional trade bias as a factory economy in the form of production fragmentation, and ASEAN + 1, specifically between ASEAN as a factory economy plus one headquarter economy USA, Japan, China, or Korea respectively. ASEAN had developed economic integration with those economies in the form of ASEAN + 1 Free Trade Agreement (FTA) between 2005–2008 (Tampubolon, 2019).

The value of the Regional Trade Introversion Index (RTII) of ASEAN + 1 will be an indicator of the ongoing re-shoring to partner countries with high technology due to industry 4.0 (robots and 3-D print) replace cheap wage labour. However, the value should be negative and the absolute value higher. The value of zero means technological progress in the fourth industrial revolution is neutral. Furthermore, the economic integration between headquarter and ASEAN as a factory enabling ASEAN economies to improve their trade competitiveness can be measured from the ongoing intra-industry trade (*IIT*) pattern. The expected result is an increase in the proportion of higher export quality in the vertical intra-industry trade (*VIIT*) from ASEAN to the headquarter economy.

Network-patterned fragmentation of production in the Asian Factory context produces intra-industry trade (*IIT*) where parts and components from the same sector are exported and imported for later upgrade to higher quality intermediates or assembly both in the factory and headquarter economy. As a factory economy, intra-industry trade amongst ASEAN countries is assumed to be horizontal, or trade of the same quality. The intra-industry trade between factory (ASEAN) and headquarter economy (USA, Japan, China, and Korea) is a vertical *IIT*, also defined as simultaneous export and import of products different by quality and technology. The most popular measure of *IIT* is the index introduced by Grubel & Lloyd (1975). It is often also referred to as Grubel-Lloyd (*GL* Index). The index is formulated as shown below

$$IIT = \frac{\sum_i^n \left[\left(X_{ij} + M_{ij}\right) - \left(X_{ij} - M_{ij}\right)\right]}{\sum_i^n \left(X_{ij} + M_{ij}\right)} \quad (6)$$

or

$$IIT = \frac{1 - |X_{ij} - M_{ij}|}{\left(X_{ij} + M_{ij}\right)}, \quad (7)$$

where X_{ij} and M_{ij} are respectively the export and import values for the sector in the trade with the country j. The sector consists of mechanical machinery and parts (HS-84), electrical machinery, equipment and parts (HS-85), and vehicle/

transportations, parts, and accessories (HS-87). Country *j* includes ASEAN countries, specifically Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam (ASEAN-6), which contribute more than 99 % to ASEAN's export value in manufacturing, especially in the three sectors referred. Since the *GL* index is calculated as *IIT* divided by total trade, the GL index should be interpreted as *IIT*'s share in total trade. It is reflected whether the pattern of business between countries indicates a vertical or horizontal division of labour. When a horizontal division of labour is established between two countries, a *GL* index should be close to one (Otsuka, 2016). Therefore, *IIT* is decomposed into Horizontal and vertical *IIT*. The most commonly used method to analyse horizontal and vertical *IIT* is to measure exports' relative unit value to imports (Abd-el-Rahman, 1991). It is expressed as follows:

$$1-\alpha \le \frac{UV_j^x}{UV_j^m} \le 1+\alpha, \qquad (8)$$

where, UV_j^x is the unit value of ASEAN exports to partner *j* (USA, Japan, China, and Korea, respectively), and UV_j^m is the unit value of ASEAN imports from partner *j*.

Product differentiation is represented by α in equation (8). Also, products whose unit values are closed (in a given year) are considered similar or horizontally differentiated in case the export and import unit values differ by less than α (Fontagne, Freudenberg, 1997). The α value is not uniformly determined but varies between 15 % and 25 %. Furthermore, Abd-el-Rahman (1991) used the 15 % threshold as Fontagne & Freudenberg (1997), Leitao (2010) and Sureci et. al (2016). The studies that used the 25 % threshold include Fontagne et. al (2005) and Chin et. al (2016). In this study, the 0.15 threshold is used, and therefore, the unit value ratio in formula (8) produces three intra-industry trade categories as follows.

$\frac{UV_j^x}{UV_j^m} \le 0.85$, shows vertical *IIT* for low quality exported goods,

$\frac{UV_j^x}{UV_j^m} \ge 1.15$, indicates vertical *IIT* for high quality exported goods, and

$0.85 \le \frac{UV_j^x}{UV_j^m} \le 1.15$, means *IIT* goes horizontally.

As a factory economy, ASEAN is in better condition in case the proportion of exports of goods with high quality regularly increases ($\frac{UV_j^x}{UV_j^m} \ge 1.15$).

The data used includes exports and imports from the UN Comtrade/International Trade Statistics Database Harmonised System (HS). The three sectors observed were HS-84, HS-85, and HS-87 for 2001–2018, except for Vietnam, where the available data was from 2001–2017. In vertical *IIT* analyses, the sectors were disaggregated to 4-digit HS. Since export and import data in quantity are not available in aggregate (country groups), unit value calculations between ASEAN and headquarter economy, mirror data were used. In this case, the exports of certain countries to ASEAN are recorded as ASEAN imports from the country concerned and vice versa.

Results and Discussion

ASEAN Trade Pattern in Machinery, Electronics, and Vehicles

The manufacturing industry in the ASEAN context is identical to the production of machinery, electronics, and vehicles (HS-84, HS-85, and HS-87), especially regarding parts and components (Sheng et. al, 2014). This transforms the region into a hub for trade in electrical machinery (Shujiro, Misa, 2007). In the last decade, these three sectors were the top exports. However, the electronics sector (HS-85) was recorded to have the highest exports with the most rapid growth, especially after the global financial crisis in 2009. Figure 1 shows more details.

Figure 1 shows that electrical machinery, electronics, and parts (HS-85) were the leading products in export manufacture, followed by machinery, mechanical appliance, and parts (HS-84). This reflects the ASEAN-6 export composition, where the specified products (HS-85) were always in the first rank, except for Thailand (the second, with HS-84 in the first place). Indonesia, which is currently generating oils and palm oils as the main exports, had electrical machinery in the third position (Tampubolon, 2019). According to Figure 2, Singapore, Malaysia, and Thailand contribute significantly to the exports of ASEAN manufactured products. Figure 2 also shows an increasing trend within the six ASEAN countries, with Vietnam enjoying the highest growth, leading Thailand and Malaysia in 2018. Indonesia and the Philippines contributed the least.

ASEAN's Intra-Industry Trade

Intra-industry trade (*IIT*) analysis confirms the fragmentation of production in machinery, electronics, and transportation (vehicle) in ASEAN, especially in the electronics, machinery, and parts

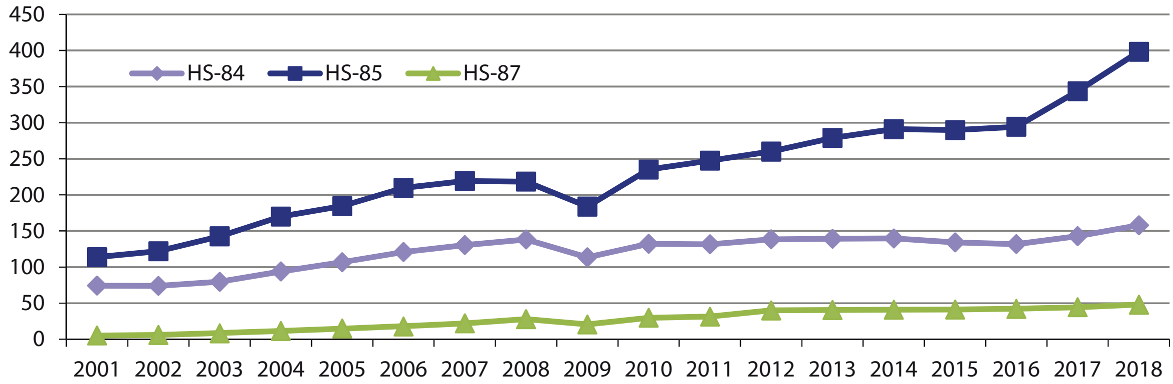

Fig.1. *ASEAN exports in the manufacturing sector, 2001 — 2018 (in billion USD)*

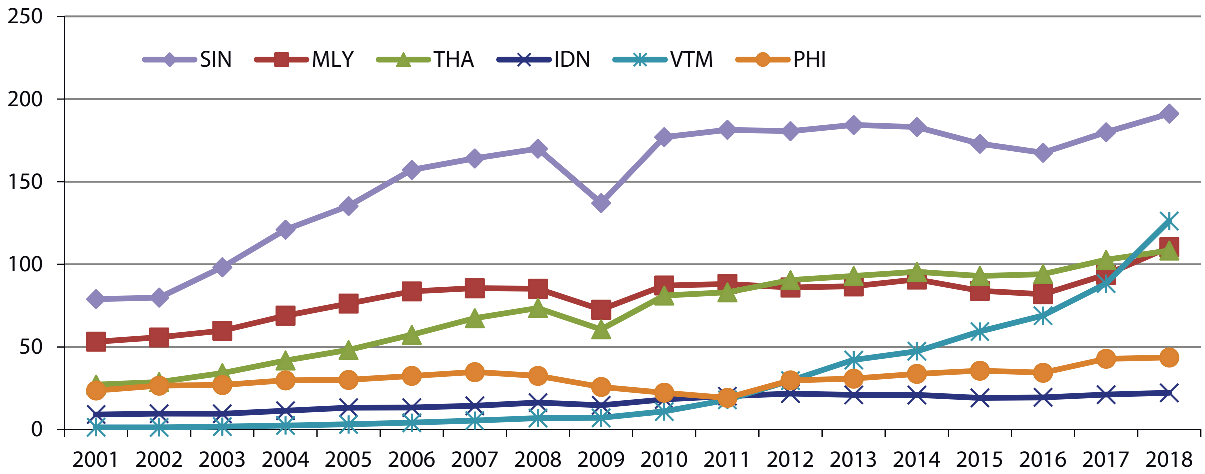

Fig. 2. *Exports in ASEAN-6's Manufacture (in Billion USD)*

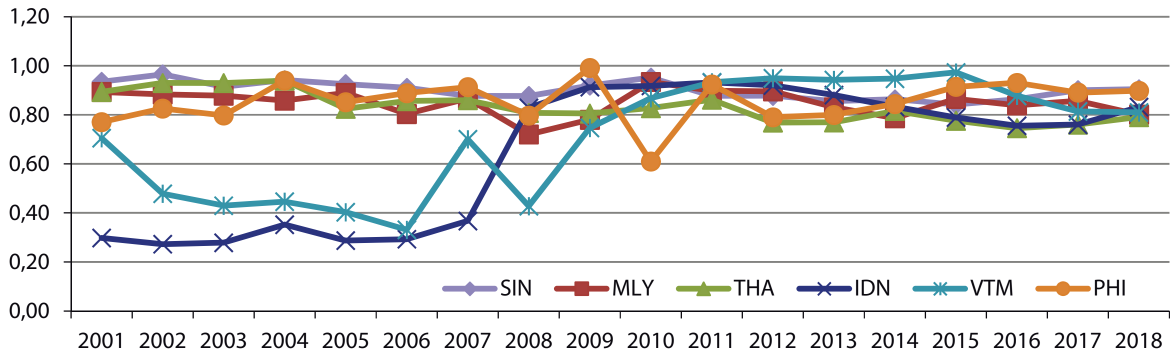

Fig. 3. *ASEAN's Intra-Industry Trade Index in electrical machinery products (HS-85)*

sectors. The GL-indices for HS-85 was close to one, although Indonesia and Vietnam began to achieve a high index consistently since 2009. This is mainly due to circumspection in trade liberalisation (Chia, 2010; Kleiman, 2013). Figure 3 shows the ASEAN's intra-industry trade indices in electrical machinery products.

Intermediate goods are important items traded by ASEAN. The high proportion of intra-industry trade involves intermediate goods categorised as import to export supply-chain trade concept (Baldwin, Lopez-Gonzalez, 2015; Ueki, 2011). The sustainability of intra-industry trade among ASEAN countries is not autonomous. It depends on the developed countries (headquarter economy) that arrange production networks by providing technology and services (managerial and manufacturing know-how) while factory economies provide labour. Around one-third of ASEAN exports contain imports from other countries (Yi, 2017; ASEAN-Japan Center, 2019). Since 2009 (post-global financial crises), around 75 % of the gross import in the electronics sector has been intermediate, and around 60 % of this proportion has been re-exported in a more advanced form. Among those foreign inputs, the most critical source country until the beginning of the 2000s had long been Japan, followed by the USA (Yi, 2017).

Trade Interdependency between ASEAN and Japan, USA, China, and Korea

Table 1 shows the regional trade introversion index (RTII) analysis for ASEAN and ASEAN + 1 in manufacturing products. There is a high interdependency among the ASEAN countries, especially the vehicle sector (HS-87) and mechanical machinery (HS-84). Also, there is a positive and high intra-regional bias between ASEAN + Japan and ASEAN + Korea in all three sectors. The ASEAN + USA trading block has shown an extra-regional trade bias due to the weak interdependency between them since 2001. ASEAN + China shows mixed results. For instance, in the vehicle sector, the ASEAN + China trade block shows a high interdependent trade (intra-regional bias), but the RTI index has turned to negative (extra-regional bias) in the electronics sector since 2005. The interdependency rate in the machinery sector is still positive but continuously decreasing and approaching zero since 2010. This is in line with the assertion that domestic industries in Southeast Asia have increased their participation in Northeast and Southeast Asia production networks compared to China's (Yi, 2017). The overall ASEAN + China RTI Index value for all manufacturing sectors decreased from 0.4457 in 2001 to –0.0372 in 2010 and –0.0432 in 2018.

The ASEAN RTI Indices show higher values than the RTI Indices in the ASEAN + 1 headquarter economy. During the fourth industrial revolution, particularly after the global financial crises, the interdependence among ASEAN countries as elements of the ASEAN factory economy is stronger, indicated by high intra-regional trade and involving all countries observed.

The increasingly weak interdependency between ASEAN and the USA (since 2014 has negative value on all products) underlines that geography is a critical determinant of the ease of participating in Asian Factory (Baldwin, Forslid, 2014). The same way it is easier to set up a supply plant in or near an industrial district, joining the Asian Factory is much easier for the nation proximate to headquarter economies in East Asia (Japan, China, Korea). This study's findings do not support the view that the importance of Japan as a supplier of intermediates in the regional production networks has been declining, unlike China and Korea, with increasing trends. The ASEAN + Japan RTII remains higher than the ASEAN + China interdependency, particularly in the machinery and electronics sector.

Table 1

Regional Trade Introversion Indices for ASEAN and ASEAN+1 in Manufacturing Products

Region	2001	2005	2010	2013	2014	2015	2016	2017	2018
	Machinery, mechanical appliance, and parts (HS-84)								
ASEAN + Japan	0.4962	0.5353	0.5422	0.6042	0.5913	0.5698	0.5300	0.5192	0.5188
ASEAN + USA	–0.1805	0.0076	–0.0549	–0.1207	–0.1623	–0.2131	–0.1803	–0.1850	–0.1854
ASEAN + China	0.4264	0.2420	0.0109	0.0491	0.0252	0.0374	0.0596	0.0171	–0.0183
ASEAN + Korea	0.5343	0.6114	0.5330	0.589	0.5680	0.5466	0.5388	0.5393	0.4915
	Electrical machinery, electronics, and parts (HS-85)								
ASEAN + Japan	0.5020	0.4711	0.4569	0.4564	0.4480	0.4332	0.4065	0.3938	0.3672
ASEAN + USA	0.0167	0.1251	0.0386	0.0047	–0.0019	–0.0406	–0.0273	–0.0386	–0.0322
ASEAN + China	0.2244	–0.0632	–0.3217	–0.4377	–0.3780	–0.4230	–0.4069	–0.3517	–0.3462
ASEAN + Korea	0.4614	0.3719	0.3584	0.3820	0.3595	0.3601	0.3880	0.3844	0.3373
	Vehicles/transportations, parts, and accessories (HS-87)								
ASEAN + Japan	0.1251	0.3275	0.4760	0.5684	0.5685	0.5545	0.5493	0.5469	0.5673
ASEAN + USA	–0.9086	–0.7209	–0.5006	–0.5491	–0.5469	–0.6037	–0.5637	–0.5516	–0.5165
ASEAN + China	0.4457	0.8218	0.5656	0.5280	0.4930	0.5687	0.5681	0.5407	0.5248
ASEAN + Korea	0.6749	0.7277	0.6869	0.6376	0.6402	0.6162	0.6576	0.6740	0.6948
HS Code	**Regional Trade Introversion Index ASEAN**								
84	0.6187	0.6927	0.6422	0.6564	0.6590	0.6376	0.6283	0.6179	0.6048
85	0.5209	0.5080	0.5115	0.4448	0.4326	0.4162	0.3957	0.3653	0.3264
87	0.8750	0.9372	0.9161	0.9061	0.9105	0.8987	0.9101	0.9139	0.9144
Total	0.6512	0.6790	0.6468	0.6244	0.6205	0.6007	0.5947	0.5756	0.5521

Source: Author's calculation.

Vertical Intra-Industry Trade between ASEAN and the USA, Japan, China and Korea

Intra-industry trade (*IIT*) analysis shows different Vertical Intra-Industry Trade (*VIIT*) patterns between ASEAN and headquarters economies. Countries with the most advanced technology, such as the USA and Japan, continue to make ASEAN a 'factory' produce low technology components and parts. Therefore, the composition of *VIIT* with lower quality products is very high. These low-quality products are most likely not to be processed domestically. They can be re-exported to other factory economies. The *VIIT* with new headquarter economies, such as China and Korea, is dominated by exports of higher quality products, where the electronics sector shows a consistent surge in *VIIT* with higher quality exports. This indicates the increasing ability of the ASEAN electronics sector to adapt to technological advances through the implementation of Industry 4.0. Table 2 shows the proportions of ASEAN exports with higher and lower quality to headquarter economies by product categories. It indicates that high-tech exports from ASEAN to China and Korea are higher than those of the USA and Japan. In addition, the imports from the USA and Japan are dominated by high-tech imports (Yi, 2017). This shows that the ASEAN electronics sector's increasing ability to adapt to technological advances is still limited to medium-high-tech in the form of advanced intermediate for further processing in China and Korea (the new headquarter).

Figure 4 shows the value of ASEAN exports to the headquarter economies as a whole. In 2001, the exports were dominated by low-quality products. The high-quality products were large with similar quality (horizontal *IIT*). In the last two decades, the values of exports of both high and low-quality products were increasing. However, the increase in the value of exports of high-quality products was more rapid. Consequently, its value consistently exceeded the lower quality exports in the last ten years. The figure also shows that horizontal *IIT* is increasingly meaningless. The ASEAN was no longer exporting or importing parts and components with a similar quality

Table 2

Share of VIIT between ASEAN and Headquarter Economy in Manufacture Export (in %)*

Description		2001	2005	2009	2013	2017
ASEAN Export to:		*Machinery, mechanical appliance, and parts (HS-84)*				
Japan	VIIT higher quality	23.20	21.19	3.02	5.08	35.75
	VIIT lower quality	15.88	77.90	88.65	83.23	61.10
USA	VIIT higher quality	1.20	1.25	0.86	5.65	6.11
	VIIT lower quality	70.93	74.48	96.24	90.66	92.24
China	VIIT higher quality	62.55	31.10	31.52	43.49	49.49
	VIIT lower quality	0.50	0.33	67.55	54.44	50.19
Korea	VIIT higher quality	93.10	72.95	93.71	87.05	83.54
	VIIT lower quality	0.45	7.98	3.22	10.94	10.56
ASEAN Export to:		*Electrical machinery, electronics, and parts (HS-85)*				
Japan	VIIT higher quality	41.85	11.09	36.36	22.54	28.83
	VIIT lower quality	54.58	72.70	39.19	52.10	58.35
USA	VIIT higher quality	1.36	6.44	46.43	17.95	13.17
	VIIT lower quality	83.93	91.94	50.49	79.93	84.42
China	VIIT higher quality	16.10	15.78	94.30	91.63	98.28
	VIIT lower quality	13.31	2.40	4.93	4.85	0.28
Korea	VIIT higher quality	83.20	96.71	95.99	94.50	56.06
	VIIT lower quality	16.78	2.18	3.21	4.85	6.92
ASEAN Export to:		*Vehicles/transportations, parts, and accessories (HS-87)*				
Japan	VIIT higher quality	2.86	3.10	1.64	0.98	14.97
	VIIT lower quality	78.65	96.88	20.09	39.56	5.64
USA	VIIT higher quality	96.67	99.18	99.98	97.13	72.96
	VIIT lower quality	0.01	0.69	0.00	2.87	24.95
China	VIIT higher quality	89.22	98.99	50.32	96.22	61.45
	VIIT lower quality	10.09	0.03	35.34	2.28	33.32
Korea	VIIT higher quality	82.30	92.44	98.42	99.15	96.96
	VIIT lower quality	1.98	3.14	0.57	0.85	2.97

* The horizontal proportion of *IIT* with each headquarter economy = 100 – (*VIIT* higher quality + *VIIT* lower quality).
Source: Author's calculation.

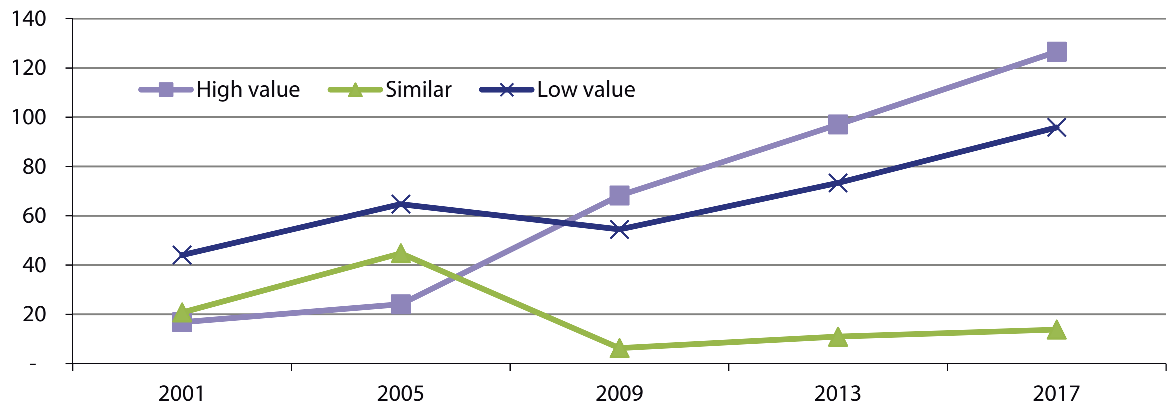

Fig. 4. *ASEAN's Vertical Intra-Industry Trade in Manufacture to Headquarter Economies (in Billion USD)*

to and from headquarter economies. Additionally, the high quality of exports contains high domestic value-added (64 % in 2016), contributing directly to gross domestic product (ASEAN-Japan Center, 2019)

In the fourth industrial revolution era, ASEAN with production fragmentation in the structure of headquarter and factory economies has not experienced significant changes in functions. ASEAN could show an increase in technological content for its manufacturing products with higher domestic value-added. This is indicated by an increase in the export of higher quality products, especially to new headquarter economies. The increase in real wage in ASEAN as factory economies is likely to be cancelled by a more significant increment in total factor productivity through the application of more efficient technologies in production and a significant reduction in prices of intermediate inputs (Moore's law) and electricity (due to infrastructure development). A similar phenomenon was observed in the Korean manufacturing industries between 1994 and 2010 (Fukao et. al, 2016). Further observations indicate a differentiation among ASEAN countries that follows the previous pattern of production fragmentation.

The Asian factory economy begins with a hollowing out of the Japanese economy. The Japanese firms produce certain high-tech parts domestically and send labour-intensive production (including assembly) to East Asian countries through foreign direct investment in the form of foreign-affiliated firms. Spillover effect and learning process allow countries that relied on low wages to improve their technological capabilities and develop NIEs (Korea, Taiwan, Hong Kong, and Singapore) (Baldwin, 2008; Baldwin, Lopez-Gonzalez, 2015; Yi, 2017). When NIEs experience wage increases no longer profitable for producing low-value parts, components, and products themselves, they emulate Japan by sending labour-intensive stages of production to ASEAN countries. ASEAN countries, especially the older ones, also experience spillover effects and wage increases. For this reason, they also concentrate on producing and assembling medium-high-tech parts, components, and products by making the new ASEAN countries, specifically CLMV (an acronym from Cambodia, Lao, Myanmar, and Vietnam) as factories for the production and assembly of labour-intensive stages of production (low-tech). This is indicated by the low contribution of domestic value-added exports in the GDP of CLMV countries (9–13 %) compared to old-ASEAN, which ranged from 35–63 % in 2018. The high proportion of Vietnam's exports in Figure 2 is the result of intermediate import assembly, because from gross exports, only 12 % is contributed by domestic value-added. Vietnam exports are growing, but much of their value goes to foreign countries, with a small domestic value-added.

Technologically advanced countries are also increasingly differentiated. The most advanced countries are focused on research and development (R&D) based products (Yi, 2017). Other studies referred to them as intellectual capital[1] in cognitive and creative activities that depend less on physical equipment and structures. They depend more on intangible assets, such as intellectual property and organisational and human capital (Brynjolfsson, McAfee, 2014; Schwab, 2016). The new technological advanced countries are suppliers of high-tech components from domestic firms; they hollow out labour-intensive production stages to the least developed countries for further processing into medium-high-tech products in developing countries. Therefore,

[1] Romanova, O. A. (2019). Priorities of Russia's Industrial Policy Amid the Challenges of Fourth Industrial Revolution Part 2 (translation). Retrieved from: https://www.google.com/search?q=Priorities+ of+Russia%E2%80%99s+Industrial+Policy+Amid+The+Challenges+of+Fourth+Industrial+Revolution&ie=utf-8&oe=utf-8&client=firefox-b (Date of access: 30.10.2019).

there is more trade in intermediate goods with different levels of technology from medium to high-tech.

In the automotive industry, a car is now a computer on wheels, with electronics representing roughly 40 % of its total cost. The participation of technological companies such as Google, Tesla and Xiaomi in automotive markets, and their becoming major players in autonomous cars' development shows technology and licensing software might be strategically more beneficial than manufacturing the cars per se (Schwab, 2016). The most advanced technology headquarter economies may focus on providing technologies in the form of industrial design and software. Contrastingly, the new advanced countries take over the role to arrange the production of parts, components, and final goods, following the latest technological developments required by factory economies with low-skilled labour. This is applied in the production of electronics, computers, and optical instruments by adopting high automation and the introduction of labour-saving technologies, such as robots and 3-D printing. However, they require parts and components for their smart factories (Hallward-Driemeier, Nayyar, 2018).

The electronic and ICT sectors may experience significant growth since they supply the technologies likely to be sought by other industrial sectors in the Industry 4.0. Due to the strong regional clustering in ASEAN that includes the production of parts and components with the simplest technology to medium-high-tech, the sector and the region would be relatively unaffected by automation in the short run.

Conclusion

In the early stages of the fourth industrial revolution era, there is no disruption in factory Asia. This is the source of economic growth and prosperity in the East Asia region. The ASEAN trade block is getting stronger. In addition, there are indications that the headquarter economies are not homogeneous but are differentiated between the most technological advances and the new headquarter. The most advanced economy focuses more on R&D based products with high value and engages more in trade in services. With these countries, ASEAN trade is VIIT with lower quality. Simultaneously, the new advanced economies, including China and Korea, are more involved in trading goods as suppliers of high-tech parts and components. In this regard, ASEAN shows the ability to adapt to technological advances to export medium-high-tech intermediates and products that provide VIIT with higher quality and high content of domestic value-added.

There is differentiation among ASEAN countries as a factory economy. The new ASEAN countries (CLMV, or Cambodia, Lao, Myanmar, and Vietnam) play the role of assimilatory labour-intensive intermediates, which are cheap with low domestic value-added content. The old ASEAN countries (Brunei, Indonesia, Malaysia, the Philippines, Singapore, and Thailand) are medium-high-tech intermediate assemblies and more expensive products with high domestic value-added. There is still the possibility of differentiating the old ASEAN between Singapore and Malaysia as the emerging new headquarter with the rest as a factory.

Apart from the differentiation and development of production networks, ASEAN, as the hub of parts and components in the electronics sector, continues to function in the short run. Various advancements in Industry 4.0 technology-based production with its main elements such as smart factories, internet of things, robotic and autonomous vehicles require parts, components, and electronic and ICT products.

An increasingly complex structure, examining how ASEAN deals with the fourth industrial revolution, requires a network pattern approach between ASEAN countries and headquarter. The database used should be at the product level (not sector), specifically, HS-four-digit equipped with value-added analysis. In this case, each ASEAN country's position and the benefits derived from its involvement in regional production fragmentation can be evaluated. Therefore, ASEAN, as a cooperation entity, may formulate policies benefiting member countries. This is in line with the ASEAN Economic Community (AEC) objective of increasing participation in global supply chains.

References

Abd-el-Rahman, K. (1991). Firms Competitive and National Comparative Advantages as Joint Determinants of Trade Composition. *Weltwirtschaftiches Archiv, 127(1),* 83–97. Retrieved from: https://www.digizeitschriften.de/ dms/img/?PID=PPN345575296_0127 %7Clog9 (Date of access: 11.09.2019).

Ando, M. & Kimura, F. (2003). *The Formation of International Production and Distribution Networks in East Asia*. NBER Working Paper No. 10167. Retrieved from: http://www.nber.org/ papers/w10167 (Date of access: 25.07.2019).

ASEAN-Japan Center (AJC). (2019). *Global Value Chains in ASEAN: A Regional Perspectives*. ASEAN-Japan Center. Retrieved from: https://www.asean.or.jp/en/centre-wide-info/gvc_database_paper1/ (Date of access: 02.07.2020).

Baldassarre, F., Ricciardi, F. & Campo, R. (2017). The Advent of Industry 4.0 in Manufacturing Industry: Literature Review and Growth Opportunities. *DIEM (Dubrovnik International Economic Meeting), 3(1),* 632–643. Retrieved from: https://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=276313 (Date of access: 27.03.2019)

Baldwin, R. & Forslid, R. (2014). The Development and Future of Factory Asia. In: *B. Ferraini (Ed.), Asia and Global Production Networks: Implications for Trade, Incomes and Economic Vulnerability* (pp. 338–368). Cheltenham, UK & Northampton, MA, USA: Edward Elgar.

Baldwin, R. & Lopez-Gonzalez, J. (2015). Supply-Chain Trade: A Portrait of Global Patterns and Several Testable Hypotheses. *The World Economy, 38(11),* 1682–1721. DOI: https://doi.org/10.1111/twec.12189.

Baldwin, R. E. (2008). Managing the Noodle Bowl: the Fragility of East Asian Regionalism. *The Singapore Economic Review, 53(3),* 449–478. DOI: https://doi.org/10.1142/S0217590808003063.

Bartodziej, C. J. (2017). *The Concept Industry 4.0: An Empirical Analysis of Technologies and Applications in Production Logistic.* Wiesbaden: Springer Gabler, 150.

Bernardino, N. Y. (2004). *The ASEAN-China Free Trade Area: Issues and Prospects. Asia Pacific Network on Food Sovereignty* (Regional Workshop Papers). Retrieved from: https://twn.my/title2/FTAs/General/ASEAN-China_FTA_N.Bernardino.pdf (Date of access: 02.03.2022).

Bogoviz, A. V., Osipov, V. S., Christyakova, M. K. & Borisov, M. Y. (2019). Comparative Analysis of Formation of Industry 4.0 in Developed and Developing Countries. In: *E. G. Popkova (Ed.), Industry 4.0: Industrial Revolution of the 21st Century* (pp. 155–164). Wiesbaden: Springer Gabler (eBook).

Bouet, A., Cosnard, L. & Laborde, D. (2017). Measuring Trade Integration in Africa. *Journal of Economic Integration, 32(4),* 937–977. DOI: https://doi.org/10.11130/jei.2017.32.4.937.

Brynjolfsson, E. & McAfee, A. (2014). *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies.* London: W.W. Norton, 172.

Chia, S. Y. (2010). *Regional Trade Policy Cooperation and Architecture in East Asia.* ADBI Working Paper Series No. 191. Retrieved from: https://www.adb.org/publications/regional-trade-policy-cooperation-and-architecture-east-asia (Date of access: 28.05.2018).

Chin, M.-Y., Teo, C.-L. & Puah, C.-H. (2016). Intra-Industry Trade between Malaysia and Singapore in Sitc 7: An Ardl Bound Test Approach. *International Journal of Economics and Management, 10(1),* 109–124. Retrieved from: http://www.ijem.upm.edu.my/vol10_no1.htm (Date of access: 10.10.2019).

Fontagne, L. & Freudenberg, M. (1997). *Intra-Industry Trade: Methodological Issues Reconsidered.* CEPII Working Paper No. 1997–01. Retrieved from: http://www.cepii.fr/PDF_PUB/wp/1997/wp1997–01.pdf (Date of access: 11.09.2019)

Fontagne, L., Freudenberg, M. & Gaulier, G. (2005). *Disentangling Horizontal and Vertical Intra-Industry Trade.* CEPII Working Paper No. 2005–10. Retrieved from: http://www.cepii.fr/PDF_PUB/wp/2005/wp2005–10.pdf (Date of access: 11.09.2019).

Friedman, T. L. (2000). *Understanding Globalization: The Lexus and the Olive Tree.* New York, NY: Farrar, Straus and Giroux, 394.

Friedman, T. L. (2007). *The World is Flat: A Brief History of the Twenty-First Century.* London: Penguin, 488.

Fukao, K., Ikeuchi, K., Kim, Y. G, Kwon, H. U. & Makino, T. (2016). International Competitiveness: A Comparison of the Manufacturing Sectors in Korea and Japan. *Seoul Journal of Economics, 29(1),* 43–68. Retrieved from: http://www.sje.ac.kr/ (Date of access: 24.08.2019).

Grubel, H. G. & Lloyd, P. J. (1975). *Intra-Industry Trade: The Theory and Measurement of International Trade in Differentiated Products.* New York, NY: Wiley, 205.

Hallward-Driemeier, M. & Nayyar, G. (2018). *Trouble in the Making? The Future of Manufacturing-Led Development.* Washington, DC: World Bank, 221.

Hamanaka, S. (2012). *Is Trade in Asia Really Integrating?* ADB Working Paper Series on Regional Economic Integration, No. 91. Retrieved from: https://www.adb.org/publications/trade-asia-really-integrating (Date of access: 13.07.2019).

Hamanaka, S. (2015). *The Selection of Trade Integration Indicators: Intraregional Share, Intensity, Homogenous Intensity, and Introversion Index.* ADB Economics Working Paper Series No. 455. Retrieved from: https://www.adb.org/sites/default/files/publication/174919/ewp-455.pdf (Date of access: 02.07.2020).

Hermann, M., Pentek, T. & Otto, B. (2015). *Design Principles for Industrie 4.0 Scenarios: A Literature Review.* Working Paper No. 01, 2015, Technische Universitaet Dortmund. DOI: http://doi.org/10.13140/RG.2.2.29269.22248.

Iapadre, L. (2004). *Regional Integration Agreements and the Geography of World Trade: Measurement Problems and Empirical Evidence.* UNV-CRIS e-Working Papers, W-2004/3, 21. Retrieved from: https://collections.unu.edu/view/UNU:7215 (Date of access: 02.07.2020).

Kimura, F. & Obashi, A. (2011). *Production Networks in East Asia: What We Know So Far.* ADB Institute Working Paper, No. 320. Retrieved from: https://www.adb.org/publications/production-networks-east-asia-what-we-know-so-far (Date of access: 08.08.2019).

Kleiman, D. (2013). *Beyond Market Success? The Anatomy of ASEAN's Preferential Trade Agreements.* European University Institute Working Papers, No. 01. Retrieved from: https://cadmus.eui.eu/handle/1814/26015 (Date of access: 16.06.2019).

Kojima, K. (1964). The Pattern of International Trade Among Advanced Countries. *Hitotsubashi Journal of economics, 5(1),* 16–36. Retrieved from: https://core.ac.uk/download/pdf/6835715.pdf (Date of access: 02.07.2020).

Leitao, N. C., Faustino, H. C. & Yoshida, Y. (2010). Fragmentation, Vertical Intra-Industry Trade, and Automobile components. *Economics Bulletin, 30(2),* 1006–1015. Retrieved from: https://ideas.repec.org/a/ebl/ecbull/eb-09–00507.html (Date of access: 27.08.2019).

Liao, Y., Loures, E. R., Deschamps, F., Brezinski, G. & Venancio, A. (2018). The Impact of the Fourth Industrial Revolution: a cross-country/region comparison. *Production, 28.* Retrieved from: http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0103–65132018000100401&lng=en&tlng=en (Date of access: 31.05.2019).

Liu, C. (2017). International Competitiveness and the Fourth Industrial Revolution. *Entrepreneurial Business and Economic Review, 5(4),* 111–133. DOI: http://doi.org/10.15678/EBER.2017.050405.

Otsuka, K. (2016). Intra-Industry Trade in East and South East Asia: Comparative Advantage and Expansion of Regional Production Network. *The Ritsumeikan Economic Review, 64(5),* 61–70. Retrieved from: https://core.ac.uk/ /download/pdf/60550230.pdf (Date of access: 12.06.2019).

Popkova, E. G., Ragulina, Y. V. & Bogoviz, A. (2019). Fundamental Differences of Transition to Industry 4.0 from Previous Industrial Revolutions. In: *E. G. Popkova (Ed.), Industry 4.0: Industrial Revolution of the 21st Century* (pp. 21–28). Wiesbaden: Springer Gabler (eBook).

Pozdnyakova, U. A., Golikov, V. V., Peters, I. A. & Morozova, I. A. (2019). Genesis of the Revolutionary Transition to Industry 4.0 in the 21st Century an Overview of Previous Industrial Revolution. In: *E. G. Popkova (Ed.), Industry 4.0: Industrial Revolution of the 21st Century* (pp. 11–19). Wiesbaden: Springer Gabler (eBook).

Rojko, A. (2017). Industry 4.0 Concept: Background and Overview. *International Journal of Interactive Mobile Technologies (iJIM), 11(5),* 77–90. Retrieved from: https://online-journals.org/index.php/i-jim/article/view/7072 (Date of access: 27.03.2019).

Schwab, K. (2016). *The Fourth Industrial Revolution.* Geneva: World Economic Forum, 154.

Shapiro, R. (2008). *Futurecast 2020: A Global Vision of Tomorrow.* London: Profile Books, 358.

Sheng, Y., Tang, H. C. & Xu, X. (2014). The Impact of ACFTA on People's Republic of China-ASEAN Trade: Estimates Based on an Extended Gravity Model for Component Trade. *Applied Economics, 46(19),* 2251–2263. DOI: http://doi.org /10.1080/00036846.2014.899676.

Shujiro, U. & Misa, O. (2007). *The Impact of Free Trade Agreements on Trade Flows: An Application of the Gravity Model Approach.* RIETI (The Research Institute of Economy, Trade and Industry) Discussion Paper Series, No.7-E-052. Retrieved from: https://www.rieti.go.jp/en/publications/summary/07080011.html (Date of access: 12.11.2019).

Sorhun, E. (2014). What Kind of Trade Integration Would the SCO's Further FTA be? In: *U. Hacioglu, H. Dincer (Eds), Globalization and Governance in the International Political Economy* (pp. 63–73). Hershey, PA: IGI Global.

Stiglitz, J. E. (2007). *Making Globalization Work.* New York, NY: W.W. Norton, 400.

Sureci, Y., Tahiri, Y. G. & Tahiri, Y. (2016). Measurement of Vertical and Horizontal Intra-Industry Trade in Agricultural Food Products: The Case of China and Brazil. *Journal of Academic Social Science Studies, 45,* 145–154. DOI: http://doi.org/10.9761/JASSS3280.

Talamo, G. & Sabatino, M. (2018). Reshoring in Italy: A Recent Analysis. *Contemporary Economics, 12(4),* 381–398. DOI: http://doi.org/10.5709/ce.1897–9254.284.

Tampubolon, J. (2019). Indonesian Export Performance and Competitiveness in the ASEAN-China FTA. *WSEAS Transaction on Business and Economics, 16,* 120–129. Retrieved from: http://wseas.org/wseas/cms.action?id=19913 (Date of access: 11.04.2019).

Ueki, Y. (2011). Intermediate Goods Trade in East Asia. In: *M. Kagami (Ed.), Intermediate Goods Trade in East Asia: Economic Deepening Through FTAs/EPAs* (pp. 24–67). BRC Research Report No. 15, Bangkok Research Center, IDE-JETRO. Retrieved from: https://www.ide.go.jp/library/English/Publish/ Reports/Brc/pdf/05_chapter2.pdf (Date of access: 02.07.2020).

Yi, A. K. J. (2017). Dynamics of Trade in Value-Added in "Factory Asia". *Journal of Contemporary Asia, 47(5),* 704–724. DOI: http://doi.org/10.1080/ 00472336.2017.1322628.

About the authors

Jongkers Tampubolon — Doctor of Development Studies, Associate Professor, Department of Agribusiness, HKBP Nommensen University; http://orcid.org/0000-0002-7142-0606; Scopus Author ID: 160-67416900 (4A, Sutomo St., Medan, 20234, Indonesia; e-mail: jtampubolon@yahoo.com).

Tongam Sihol Nababan — Doctor of Development Economics, Associate Professor, Department of Economics Development Studies, HKBP Nommensen University; https://orcid.org/0000-0001-6455-1459, (4A, Sutomo St., Medan, 20234, Indonesia; e-mail: tsnababan@gmail.com).

Об авторах

Тампуболон Йонгкерс — доктор исследований в области развития, доцент кафедры агробизнеса, Университет Nommensen HKBP; http://orcid.org/0000-0002-7142-0606; Scopus ID: 160-67416900 (Индонезия, 20234, г. Медан, ул. Сутомо, 4А; e-mail: jtampubolon@yahoo.com).

Набабан Тонгам Сихол — доктор экономических наук в области развития, доцент кафедры экономических исследований развития, Университет Nommensen HKBP; https://orcid.org/0000-0001-6455-1459, (Индонезия, 20234, г. Медан, ул. Сутомо, 4A; e-mail: tsnababan@gmail.com).

Дата поступления рукописи: 10.04.2020.
Прошла рецензирование: 29.06.2020.
Принято решение о публикации: 24.12.2021.
Received: 10 Apr 2020.
Reviewed: 29 Jun 2020.
Accepted: 24 Dec 2021.