The AEC and a Technology-Driven Industrial Catch-Up: Three ASEAN Country Cases

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ABSTRACT

There is a growing consensus that effective Science, Technology, and Innovation (STI) policies, aimed at supporting long-term national structural transformation, are a crucial element in helping latecomer countries escape from the middle-income trap. Citing cases of Northeast Asian catch-up and Latin American middle-income traps, scholars emphasize that the key to catch-up is a triple-helix coordination that is used to transform foreign technology into indigenous technological capabilities. Thus, ideally, the expansion of the global production network, as promoted by the ASEAN Economic Community (AEC), provides opportunities for middle-income ASEAN countries to implement this technology-driven industrial catch-up strategy. This paper investigates three middle-income ASEAN countries (Malaysia, Thailand, and Indonesia) to argue that the AEC, as an open market-led economic regionalism scheme, does not have the ability to create a strong sense of urgency on the part of national governments to alter their national STI policy directions. As resource-abundant countries, Malaysia, Thailand, and Indonesia have yet to find any urgent need to prioritize the upgrading of indigenous manufacturing over natural resource-based technological developments. For these three countries, the AEC amplifies the need to compete against other ASEAN member countries instead pushing them to pursue industrial catch-up collectively.

Keywords: *economic regionalism, STI, industrial catch-up, ASEAN*

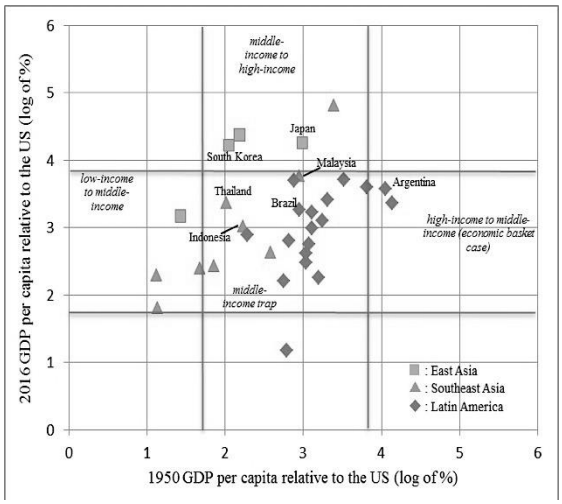
Dalam studi mengenai negara berkembang, terdapat sebuah konsesus bahwa peran kebijakan iptek dan inovasi memiliki peran crusial bagi kemampuan sebuah negara berkembang untuk lepas dari jebakan pendapatan menengah. Berbagai kajian, yang mayoritas didasarkan pada keberhasilan kasus negara-negara Asia Timur dan kegagalan kasus negara-negara Amerika Latin, telahmenekankan bahwa kunci dari keberhasilan proses catch-up adalah adanya efektifitas kerjasama triple-helix dalam proses pengembangan teknologi asing untuk mendukung pengembangan kemampuan teknologi lokal. Dalam kerangka ini maka, idealnya kerangka Masyarakat Ekonomi ASEAN (MEA) memberikan peluang yang besar bagi negara-negara berpendapatan menengah di ASEAN untuk dapat mengimplementasika strategi "technology-driven industrial catch-up". Artikel ini menginvestigasi tiga kasus negara berpendapatan menengah di ASEAN (Malaysia, Thailand, dan Indonesia) untuk berargumen bahwa MEA, sebagai sebuah skema regionalism ekonomi yang berpusatkan pada pasar, tidak mampu menciptakan tekanan atau urgensi yang kuat bagi pemerintah nasional untuk mengubah arah kebijakan iptek dan inovasi. Sebagai negara yang kaya akan sumber daya alam, Malaysia, Thailand, dan Indonesia belum dihadapkan pada level urgensi yang tinggi untuk memprioritaskan upgrading sektor manfaktur lokal diatas perkembangan teknologi yang didasarkan pada pengembangan sumber daya alam. Bagi ketiga negara tersebut, MEA memperkuat persaingan diantara negara-negara anggota ASEAN daripada memprioritaskan kebutuhan untuk bekerjasama untuk mendorong industrial catch-up secara kolektif.

Kata Kunci: *regionalisme ekonomi, STI, industrial catch-up, ASEAN*

Introduction

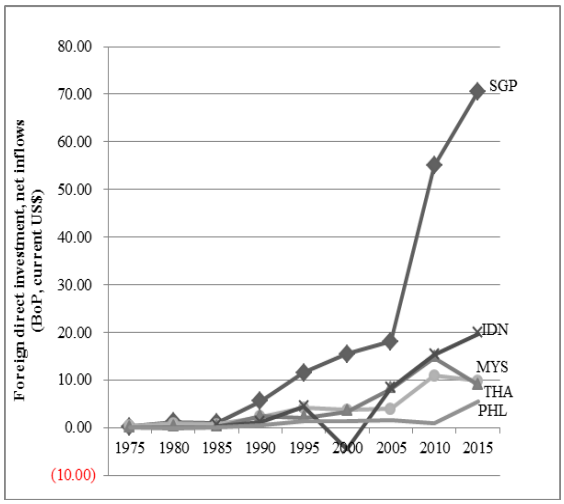
One of the continuous challenges for developing countries is to avoid the middle-income trap (see Fig. 1). There are two general approaches to the middle-income trap(Paus, 2018). The neoclassical economic approach seeks to find a universal determinant for economic slowdowns.The structural-evolutionary economic approach focuses on the nature of the productive structure of the economy and technological learning process within the context of international competitiveness. Upgrading indigenous manufacturing has become the principle focus of the structural and evolutionary economic approach. Within the past 40 years, the transitions of developing countries into countries with higher income levels have been accompanied by technological upgrades within the manufacturing subsectors[1](United Nations Industrial Development Organization, 2015). The successful catching-up experiences of some developmental states (e.g., Japan, Taiwan, South Korea) and the slower development of Latin American countries (e.g., Argentina, Brazil) have also led to a scholarly consensus on the importance of upgrading indigenous manufacturing (Fig. 1).Within this context, the national Science, Technology, and Innovation (STI) policies of the latecomer countries have received abundant attention from scholars. Technology is not free and knowledge is imperfect, thus the latecomers governments need to invest in "some adaptive engineering in order to make foreign technology work" in the globalization era (Amsden, 2001, p. 14). Triple-helix coordination (government-university-industry) becomes a crucial element in fostering technology transfer from advanced countries to developing countries (i.e., a technology-driven industrial catch-up) (Lee, 2013; Taylor, 2016; United Nations Industrial Development Organization, 2015; OECD, 2018).

Figure 1. Middle Income Trap: Relative Income 1950 and 2016 (selected countries)



Source: Maddison Project Database (Bolt, et al., 2018)

Figure 2. FDI Inflows into ASEAN-6 (1975-2015), except Brunei Darussalam



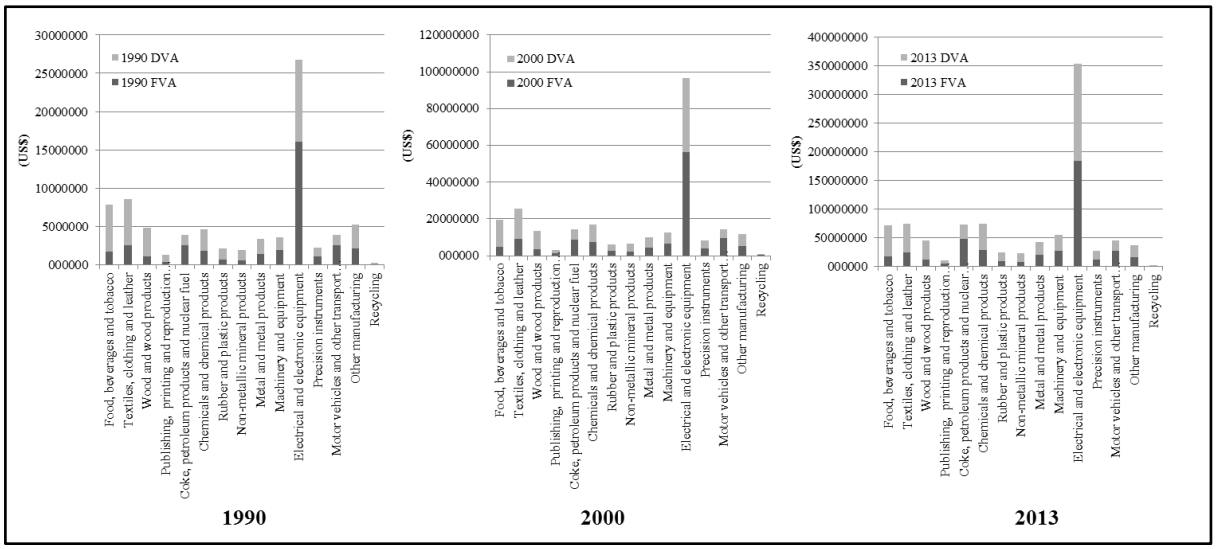
Source:(World Development Indicators, 2019)

Southeast Asian countries hold strategic positions in the middle of the global production network (global value chain). Since the 1980s, the manufacturing sector in these countries, particularly the middle-income ASEANcountries (i.e., Malaysia, Thailand, and Indonesia[2]), have been benefiting from the expansion of multinational companies (MNCs) from Northeast Asian countries (e.g., Japan, Taiwan, South Korea) (see Fig. 2 and Fig. 3). Since

[1] See OECD (2011) for the manufacturing subsector classification based on technological levels.
[2] Yet, based on the relative income calculation, these three countries remain stuck in the middle-income trap (Fig. 1).

2007, ASEAN has been building an economic regionalism framework (i.e., the ASEAN Economic Community or AEC) with the global production network expansion at its center.[3] Figure 3 shows that, since 1990, the manufactured exports from ASEAN countries have been benefiting from the global value chain expansion. The share of foreign value added remained large in 2013, particularly within its medium-technology manufacturing subsectors (e.g., electronics, automotive). In addition, based on various STI indicators provided by prominent reports,[4] the larger middle-income ASEAN countries (i.e., Malaysia, Thailand, and Indonesia) continue to have weaker technological capabilities than the advanced countries, including ASEAN.

Figure 3. Share of Foreign Value Added (FVA) and Domestic Value Added (DVA) in Value Added Export from ASEAN (Manufacturing Subsectors)



Source: ASEAN-Japan Center's Database on Global Value Chain (ASEAN-Japan Centre, 2018)

Therefore, the question is how can such a situation be explained? Overall, this paper argues that the AEC, as an open market-led economic regionalism scheme, cannot create a sense of urgency on the part of national governments to pursue a technology-driven industrial catch-up, in sharp contrast to the Northeast Asian developmental states (Section 2.b.). As the AEC scheme continues to smooth the expansion of the global production network into ASEAN countries, as it has since 2007, three middle-income ASEAN countries (Malaysia, Thailand, and Indonesia) have yet to alter their prioritizations of resource-based economic planning (i.e., the path-dependent nature of their economic systems) and their resource-centric national STI policies (e.g., energy efficiency, climate issues, agricultural and food sectors). The AEC scheme actually amplifies the competition among ASEAN member countries rather than producing the collective will to pursue catch-up to the technologically advanced countries (i.e., the ASEAN external partners).

Connecting Economic Regionalism and National Science, Technology, and Innovation Policies

[3] At that time, the main concern was supporting regional economic recovery in the aftermath of the 1997/98 Asian Financial Crisis (ASEAN, 2008).

[4] Various STI reports, such as the OECD STI Outlook 2016, present some of the latest STI developments in these three countries by evaluating an index of the capacity to innovate (e.g., gross domestic expenditure on R&D, education expenditure) (OECD, 2016a).

In an era of global production networks driven by MNCs, indigenous latecomer manufacturing firms are exposed to more opportunities to increase their technological capabilities through subcontracting schemes. However, as technological spillover is not an automatic process, an active role on the part of a national innovation system in latecomer countries through a national STI policy is necessary in order to help their indigenous manufacturing firms develop foreign technology. At the middle-income level, a country can no longer rely on low-technology specialization due to its inability to generate higher incomes. Latin American countries which are either trapped in the middle-income trap or have become economic basket cases represent examples of national governments that chose to rely on foreign technology (Amsden, 2001; Lee, 2013). Ideally, a form of open market-led economic regionalism facilitating foreign direct investment (FDI) for developing countries can provide more opportunities for national governments to increase their national technological capabilities as a foundation for a sustained economic growth. The two following subsections seek to discuss the flaws in this logic.

a.Market-Led Economic Regionalism and the Risk of a Passive FDI-Dependent Strategy

The discussion of economic regionalism is deeply intertwined with the globalization study, particularly the economic interpretation of globalization. Following Bisley(2007), in general, scholars of globalization study can be categorized into three groups based on how they assess globalization's fundamental characteristics: the economic interpretation, the sociological transformation, and the political conceptions. Writings on globalization first emerged in late 1980s, which mostly about pattern of social life. In early 1990s, it started to manifest in form of global economic system and slowly provokes debate about the role of state (e.g. sovereignty, nationalism). Among this dynamics, the mid-1990s saw the emergence of an anti-globalization stance as scholars began to highlight the negative cost of globalization process (Bisley, 2007, pp. 13-15).

Essential feature of globalization is mostly about economic interpretation of globalization. Bisley (2007), referring to Bhagwati's definition, puts it as an integration process of national economies into the international economy through channels such as trade, FDI, short-term capital flows, flows of workers or human resources, and flows of technology (p. 19). One of the continuing debates within the global economic system isthe North-South gap that continues to exist (or even grows wider). Most of the critiques based its stance on the problematic global economic system that favors the advanced economies and their MNCs, in which if "other things being equal, the fast growth of the rich should slow and the slow growth of the poor should accelerate as it takes advantage of the technology already created by the rich" (Thompson & Reuveny, 2010, p. 60).Technological innovation within manufacturing sectors is the essential element for economic convergences, where the North grows to be more technologically complex while the South struggles to emulate that complex technology (Thompson & Reuveny, 2010, p. 57). Instead of repeating the same debate over the 'unfairness' aspect of the global economic system, this paper seeks to investigates how developing economies (national government) react or behave toward the opportunities within the global economic system.

Economic regionalism framework, such as AEC, provides opportunities for national government to pursue industrial catch-up strategy particularly through indigenous manufacturing sector development (United Nations Industrial Development Organization, 2015). The three middle-income ASEAN countries currently holds strategic positions in the global production network, which is the basis of AEC framework. The question is, how far it provokes national governments to maximize this opportunity?Unlike the European Union

(EU), a form of old or closed regionalism[5](Haas, 1961; Balassa, 1961), ASEAN chose to form an open market-led economic regionalism though the AEC (Chaisse & Gugler, 2010; Plummer & Chia, 2015). ASEAN was established to maintain regional peace in the face of inter-state tensions and to contain the spread of communism during the Cold War (Tarling, 2006; Beeson, 2009; Weatherbee, 2015). Hence, ASEAN has used a consensus-based decision-making principlesince its inception in 1967 (ASEAN, 2019b). The1997/98 Asian Financial Crisis strengthened the importance of FDI from outside ASEAN (mainly from Japan) and resulted in an ASEAN Plus Three[6]arrangement in 1999 and the Chiang Mai Initiative in 2000. They finally agreed on the AEC Blueprint in 2007 (Plummer & Chia, 2015; Soesastro, 2005).

There remains a risk that a passive, FDI-dependent policy might follow. Such a passive, outward-looking, FDI-dependent strategy often underestimates the difficulties of internalizing technological spillovers (Narula & Dunning, 2010, p. 272). Thus, it leads to difficulties in terms of upgrade manufacturing capabilities (Lall & Narula, 2004, p. 461). As argued by Fu, Pietrobelli, and Soete (2011), "without proactive indigenous innovation efforts, foreign technology remains only static technology embedded in imported machines which will never turn into real indigenous technological capabilities" (p. 1210). Capabilities convergence matters more than income convergence in terms of middle-income countries escaping from the middle income trap. A country can fall into the middle-income trap when it "can no longer compete internationally in standardized, labor-intensive commodities because wages are relatively too high, but it can also not compete in higher value-added activities on a broad enough scale because productivity is relatively too low" (Paus, 2018, p. 65). National government support of indigenous manufacturing technological capabilities matters.

b. The Origin of Technology-Driven Industrial Catch-Upand the Problem of Path-Dependence

The current momentum regarding national STI policy as a part of an industrial catch-up strategy originated mostly from successful Northeast Asian catch-up experiences (e.g., Japan, Taiwan, South Korea)[7]and assigns national governments to be the main actors. A triple-helix cooperation (government-university-industry) is the key in technological dissemination to support the upgrading of indigenous manufacturing sectors. Since the mid-1970s, South Korea and Taiwan have been relying on government-funded research institutes to disseminate technology to private indigenous manufacturing firms (Shin, et al., 2012; Lee, 2013; Taylor, 2016). In addition, there is a lesson learned from the failure of Latin America (e.g., the Prebisch-Singer hypothesis) in terms of the problem of overreliance over primary product (Gereffi & Wyman, 1990; Kharas & Kohli, 2011). Lee (2013)suggests that a resource-based development strategy (e.g., biotechnology) only provides small windows of opportunities due to the risk of resource unsustainability and high competition, making it a high-technology replication strategy due to high-income countries' technological domination (p. 129).

The problem, however, is that this catch-up strategy was constructed from the experiences of natural resource-scarce countries (e.g., Japan, South Korea), which, during their initial catch-up stage were exposed to specific vulnerabilities, such as regional security threats, that were translated into a higher level of urgency on the part of national governments to follow such strategies (Doner, Ritchie, & Slater, 2005; Ohno, 2018). Not only does that same vulnerability not exist for the three middle-income ASEAN countries, but an evaluation of

[5]Within an old/closed regionalism, the basic objective is to construct a regional economic bloc to protect its member countries against non-member countries(Hettne & Söderbaum, 2000).
[6] ASEAN Plus Three includes ASEAN member countries and Japan, South Korea, and China.
[7] See Lundvall and Borrás (2005)

the national STI policies of the three countries (Section 4) highlights how these three countries exhibit the path-dependence problem as natural resource-abundant countries (David, 1994; Martin & Sunley, 2006; Rypestøl, 2017). Governments in natural resource-abundant countries tend to place natural resource development at the center of their national economic development strategies (i.e., agriculture, resource-based industry, bio-technology) unless there is a disruption on this strategy.

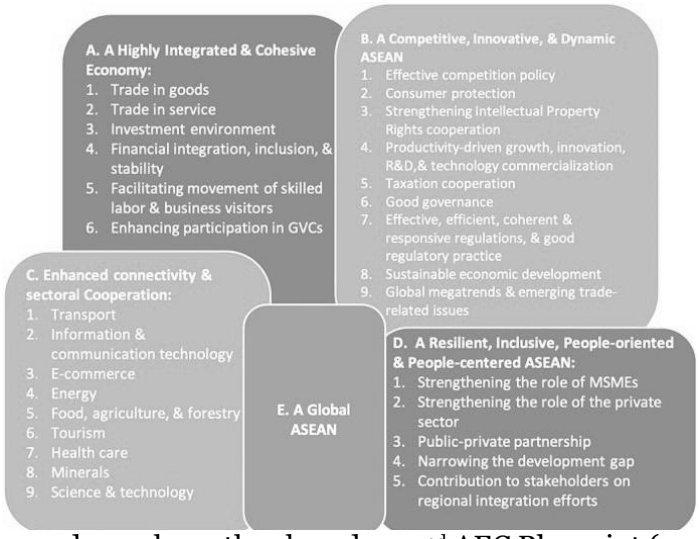
Evaluating the ASEAN Economic Community and Its STI Development Schemes

Since its inception, the AEC main framework has sought to facilitate the global production network expansion into ASEAN countries, as presented in its first blueprint in 2007 (Fig. 4), which covered largely the harmonization of regional trade regulations. In 2015, ASEAN released a new AEC Blueprint that emphasizes indigenous industrial development. It contains five AEC characteristics (Fig. 5), and its second characteristic, Characteristics B, encompasses most of ASEAN's efforts to support industrial competitiveness in order to move up the GVC (pp. 12-21). The STI development schemes are the main strategy listed for Productivity-driven Growth, Innovation, Research and Development, and Technology Commercialization (i.e. Characteristic B, Element 4).

Figure 4. ASEAN Economic Community 1st Blueprint (2007)

Source: drawn by author based on 1st AEC Blueprint (2008)

Figure 5. ASEAN Economic Community 2nd Blueprint (2015)



Source: drawn by author based on 2nd AEC Blueprint (2015)

In their second blueprint, ASEAN acknowledges "the critical role of technology adaptation and diffusion, as well as innovation in ASEAN's productivity growth and long-term competitiveness" as an important factor in pushing its member countries to improve their innovation and technological capabilities (ASEAN, 2015, p. 16). ASEAN understands that ASEAN member countries face challenges such as weak investments in R&D activities, weak human capital development, and technology diffusion problems. Thus, ASEAN established a regional-level framework for STI cooperation to facilitate the manufacturing sector upgrading (i.e., move up the GVC). The AEC Consolidated Strategic Action Plan 2018 stresses ten STI objectives to be achieved by 2025, which includes increasing triple-helix cooperation, technology transfer and technology development between local and foreign-owned firms, support for small and medium enterprises' (SMEs') STI development, and industrial cluster development to support technology linkages within the GVC (ASEAN, 2018, pp. 17-19).

With regards to AEC, the ASEAN Economic Ministers (AEM) constitute the main decision-making forum. However, the sectoral body in charge of STI development is the Committee on Science and Technology (COST), which works under the guideline of the ASEAN Plan of Action on Science, Technology, and Innovation (APASTI) 2016-2025. The origin of APASTI itself goes back to 1970s, more than 30 years before the first AEC blueprint. APASTI's initial focus was more on human resource development and natural resource efficiency through STI development (ASEAN, 2017a).After the 10th ASEAN Summit, through the Vientiane Action Program 2004-2010, ASEAN acknowledged the importance of STI development in terms of enhancing ASEAN's economic competitiveness and sustaining economic growth. Thus, under the AEC schemes, APASTI began to promote an incorporation of STI development into national economic and industrial planning[8] (ASEAN, 2017b, p. 5).

Table 1. Actions for Strategic Thrust 1 & 3 of APASTI 2016-2025

[8] Aside than AEC, STI development programs under APASTI also become part of ASEAN Socio-Cultural Community, with an emphasis over human development (e.g. mobility of scientist and researcher, scholarship and fellowship grants) (ASEAN, 2017a, p. 6).

Thrust 1 "Public-Private Collaboration"	**Thrust 2** "Enterprises Support"
Actions 1. Intensify the engagement of academe, private sector and relevant partners in the planning, implementation and assessment of joint undertakings in human resource development, and research and development. 2. Enhance and sustain the utilization of the ASEAN Science and Technology Network (ASTNET) and strengthen other S&T networks to facilitate information sharing. 3. Establish policy frameworks including IPR protection, risk and benefit sharing mechanisms for joint collaboration and technology transfer among centers of excellence. 4. Strengthen existing regional STI initiatives in priority areas including Sustainable Development Goals.	*Actions* 1. Establish support mechanism such as mentorship and incentive program to support and nurture STI enterprises from start-up to the next competitive level of development. 2. Engage dialogue and other strategic partners in joint undertakings on appropriate and commercially viable STI initiatives.

Source: (ASEAN, 2017b) summarized by author

The APASTI 2016-2025 Implementation Plan includes two strategic thrusts that connect directly to indigenous industrial competitiveness (i.e., Thrust 1 and Thrust 3[9]) (Table 1) (ASEAN, 2017b, p. 3). Under APASTI and other COST projects, ASEAN completed a series of STI projects.[10] Table 2 shows that, between 2007 and 2016, most ASEAN STI projects were related to energy, climate and disaster management, and space technology (a total of 52 projects). Training and student exchanges also received a lot of attention (26 projects). Two of the latest STI projects, started in 2016, are related to climate change issues. In sum, at the implementation level, there is lack of technological development for manufacturing sector.

Table 2. Summary of ASEAN STI Projects as reported by APASTI 2016-2025

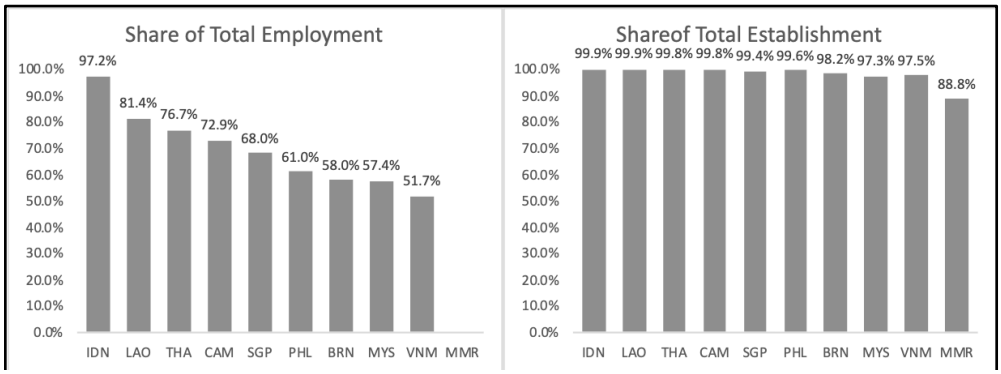
Year	*Number of Projects (total)*	*Number of Projects (manufacture industry cooperation)*		*Number of Projects (ICT / bio-informatics)*	*Number of Projects (agriculture / food)*	*Number of Projects (energy / climate & disaster management space / satellite)*	*Number of Projects (management training / student exchanges / policy workshop)*
		technology development	policy / workshop				
Completed (by)							
2007	24	-	-	6	2	14	2
2008	21	3	2	-	1	12	3
2009	9	-	-	-	2	5	2
2010	7	-	-	1	3	3	-
2011	6	-	1	-	1	4	-
2012	5	-	1	-	1	-	3
2013	5	-	1	-	3	-	1
2014	10	1	-	-	-	6	3
2015	12	-	1	1	1	4	5
2016	5	-	1	-	-	1	3
Ongoing (since)							
2006	1	-	-	-	1	-	-
2007	1	-	-	-	-	-	1
2013	2	-	-	-	-	-	2
2015	2	-	-	-	-	1	1
2016	2	-	-	-	-	2	-
Total	**112**	**4**	**7**	**8**	**15**	**52**	**26**

Notes: compiled and categorized by author based on project titles and the area of work of the ASEAN sub-committee in charge of each project
Source:(ASEAN, 2017a, pp. 20-27)

[9] Thrust 3 is more about small and medium enterprises (SMEs) because the majority of indigenous firms in ASEAN are SMEs (see Fig 6).
[10] In addition to STI projects, ASEAN also funded 21 other activities with the ASEAN Science Fund, mostly related to constructing action plans.

Aside from APASTI 2016-2025, ASEAN's efforts in supporting indigenous manufacturing upgrading in its member countries can also be seen in the ASEAN Industrial Cooperation (AICO) scheme and ASEAN Strategic Action Plan for SME Development 2016-2025. The AICO scheme, signed in 1996, was the main industrial cooperation scheme for all of the manufacturing sectors under the ASEAN Free Trade Area (1992). The AICO scheme offered incentives and tariff privileges (0-5%) for participating firms. As of 2005, almost all of the 129 approved AICO applications came from MNC's subsidiaries and Original Equipment Manufacturing (OEM) firms (ASEAN, 2012). The AICO scheme ended in 2011.

Figure 6. SMEs in ASEAN



Source: re-drawn by author (ASEAN, 2015b, p. 1)

The ASEAN scheme to support STI for SMEs is another important element because the majority of indigenous firms in ASEAN countries are micro or SMEs (Fig. 6). Within their Strategic Action Plan for SME development, ASEAN acknowledged the importance of the SME-MNC linkage (ASEAN, 2015b, pp. 8-9). The main program used to support SME's access to technology and innovation since 2013 is called the "Business and Technology Incubator," which was proposed by Indonesia (ASEAN Cooperation Project, 2013). Its technology business incubator TBI) arm aims to promote technology-based start-ups[11] (Table 3) (ASEAN Cooperation Project, 2013, p. 1). Table 3 shows that while most of the ASEAN TBI start-ups, particularly from Malaysia, Thailand, and Indonesia, are in agriculture, bio-technology, and information and communication technology (ICT) (Table 3), Japan has been chosen as the model TBI country. The six Japanese research institutions (i.e., TBI start-ups from Japan) are all involved in high technology (advanced) research and development (e.g., machinery and electronics, IT, Augmented Reality technology for smartphones) (ASEAN Cooperation Project, 2013, p. 56).

Table 3. Technology Business Incubator Respondents from Malaysia, Thailand, Indonesia

[11]Under the ASEAN Connectivity 2025 Master Plan scheme, ASEAN has a project called "Digital Innovation," which focuses on SME digitalization rather than technology development or R&D activity for SMEs.

Institution Name	*Activity Focus*
Malaysia	
1. Malaysia Technology Development Corporation Sdn Bhd Technology Center	ICT (48%), biotech (29%), life science (5%), food science (2%), electronic and electrical (5%), automotive (1%), others (7%)
2. Innovation Incubation Center – Technology Park Malaysia Corporation Sdn Bhn	IT, biotech
3. SIRIM Technology Incubation Center	General, first metal, ceramics, chemicals, biotech, ICT
Thailand	
1. Sripatum University-Business Incubator private	General: handicraft, agriculture, digital media
2. Business Incubator Center (Thai Software Park) & NSTDA Business Incubator	ICT (software) and technology-based enterprises (biotech, material technology, nanotech, electronics and computer technology)
4. Mae Jo University Business Incubator	Agriculture and food
5. Far Eastern University Business Incubator	Handicraft, Tourism, IT
Indonesia	
1. Incubie, Bogor Agricultural University	Agriculture, creative business
2. Technology Incubator Center, Agency for the Assessment and Application of Technology	IT, biotech, nanotech, manufacturing, software industry
3. Bandung Digital Valley	IT
4. Merah Putih Incubator	ICT technology (online internet start-up, social media, mobile app, games)

Source: summarized by author (ASEAN Cooperation Project, 2013)

Since 2007, the AEC has always been about the manufacturing sector. While the first blueprint was mainly about trade regulation in terms of facilitating global production expansion into ASEAN countries, the second blueprint sought to facilitate indigenous manufacturing development through an incorporation of STI development schemes. However, at the implementation level, most of the STI cooperation projects continue to be based on the idea of a 'resource-based development through technology' instead of 'technology development' to support upgrading the manufacturing sector in addition to ICT development. In the next section, this paper seeks to show that such priorities are in line with national STI policies in Malaysia, Thailand, and Indonesia.

Evaluating and Discussing the National STI Policies of Malaysia, Thailand, and Indonesia under AEC Implementation

AEC's facilitation of GVC expansion into ASEAN countries has not been followed by increasing efforts in terms of manufacturing technology cooperation among ASEAN countries. Through an examination of official government documents (Table 4), this section highlights that: (1) the national governments' concerns over AEC mostly involve competing against other ASEAN countries for FDI instead of industrial catch-up, (2) under the AEC regime (since 2007), national STI policies have continued to be linked tightly with natural resource development objectives (e.g., agricultural technology, biotechnology, environment protection, or climate technology), and (3) within the era of industry 4.0, the industry 4.0. policy plans from all three countries led to their prioritization of the 'adoption of industry 4.0' instead of 'indigenous manufacturing technology' development. Therefore, the main problem is not the lack of governments' efforts to boost STI capabilities but rather how they perceive the function of national STI policies.

Table 4. Key Government Documents and Key STI Actors

	Malaysia	**Thailand**	**Indonesia**
Main National Development Plan documents	**Malaysia Plan (MP):** 9th MP (2006-2010); 10th MP (2011-2015); 11th MP (2016-2020); 11th MP (2016-2020) Mid Term Review	**1. National Economic and Social Development Plan (NESDP):** 10th NESDP (2007-2011); 11th NESDP (2012-2016); 12th NESDP (2017-2021) **2. National Strategic Plan 2018-2037**	**1. Long-Term National Development Plan 2005-2025** **2. Short-Term National Development Plan:** 2010-2014 Short-Term Plan; 2015-2019 Short-Term Plan
Key STI Actors	1. (From 2004) Ministry of Science, Technology, and Innovation / MOSTI (From 2018) Ministry of Energy, Science, Technology, Environment and Climate Change / MESTECC 2. (From 1884) Science Advisor and (From 1993) Malaysian Industry-Government Group for High-Technology 3. (From 2010) National Innovation Agency of Malaysia 4. (From 2016) National Science Council	1. National Science, Technology, and Innovation Committee (including Prime Ministers and various ministries) 2. National Research Council of Thailand 3. Ministry of Science and Technology / MOST: ▪ National Science and Technology Development Agency / NSTDA (in charge of four high-technology centers & innovation scheme such as Industrial Technology Assistance) ▪ (From 2005) National Science, Technology, and Innovation Policy Office 4. Agriculture Research and Development Agency (under Ministry of Agriculture and Cooperative) 5. Office of the Higher Education Commission (university-based research)	1. Commission VII of House of Representative of the Republic of Indonesia 2. National Research Council 3. Ministry of Research, Technology, and Higher Education: ▪ University-based Center of Excellence ▪ National Science and Technology Park 4. Non-departmental government agencies under co-ordination with Ministry of Research, Technology, and Higher Education (e.g. Agency for the Assessment and Application of Technology; Indonesian Institutes of Sciences; National Nuclear Energy Agency; National Institute of Aeronautics and Space)

Notes: An overview of STI policy in Malaysia and Thailand can be found respectively on the report by OECD(2016b) and UNCTAD(2015). There are more STI agents (institutions) existed on Malaysia, Thailand, and Indonesia, however, table 4 only present a list of main key actors who are involved in the STI strategy planning.
Source: author

a. Malaysia:Gap between National STI Policy and National Industrial Development Strategy

Among the three countries, Malaysia currently has the highest economic growth performance, highest share of medium-high technology activities in total manufacturing value added,[12] and highest innovation performance.[13]The government of Malaysia

[12] Based on the Competitive Industrial Performance Index 2018, the share of medium-high technology activities in total manufacturing value added in Malaysia, Thailand and Indonesia in 2016, respectively, were 44.1 percent, 40.7 percent, and 25.1 percent. Their compositions of manufacturing exports show that more than 20 percent of Malaysia and Thailand's manufacturing exports are resource-based, while more than 40 percent of Indonesia's manufacturing exports are resource-based (UNIDO, 2018).

acknowledges the importance of the manufacturing sector for their economic growth. However, the MNCs have remained to be the main drivers. Their national STI policy is still tightly linked to natural resource technology development. The story of Malaysia's manufacturing growth goes back to the 1970s and the Mahathir's New Economic Policy. When Mahathir stepped down from politics in 2006, the government of Malaysia shifted their priorities into the agricultural sector and resource-based industries. When he came back into Malaysian politics in 2018, the government of Malaysia reconstructed their national economic strategy by emphasizing the manufacturing sector. Interestingly, they also decided to combine the Ministry of Science, Technology, and Innovation with the Green Technology and Energy Components from the Ministry of Energy, Green Technology, and Water and related components in Climate Change and Environment under the Ministry of Natural Resources and Environment to form the Ministry of Energy, Science, Technology, Environment, and Climate Change (MESTECC).

From the 1970s to 2006, the government of Malaysia made a decision to abandon their agricultural sector in favor of a modern economic sector through the adoption of New Economic Policy and the 2nd Malaysia Plan (1971-1975), which were provoked by the 1969 Riots.[14] The main objective in fostering structural change was to reduce the economic disparities between ethnicities that had become a primary threat to the nation's future(The Economic Planning Unit of Malaysia, 1971, p. 1).As a consequence, the government of Malaysia decided to rely heavily on FDIs instead of nurturing domestic capital, such as that for Chinese Malay businesses. This decision led to a slower pace of indigenous technology development, particularly among the smaller Chinese Malaysian-owned firms (Ritchie, 2005).

Starting in 2006, the government of Malaysia constructed their national economic strategy around agricultural development. They stated that it was "the third engine of economic growth" and that Malaysia "must think progressively and remove misperceptions that agriculture is a low value added economic activity capable of only generating small incomes" (The Economic Planning Unit of Malaysia, 2006, pp. 16-17). The government increased its spending on the agricultural sector by 70 percent from the previous plan (i.e., the Eight Malaysia Plan 2001-2005) (The Economic Planning Unit of Malaysia, 2006, p. 18). The Tenth Malaysian Plan (2011-2015) emphasized the problem of the middle-income trap, but the government continued their resource-based prioritization, as they established 12 potential National Key Economic Areas: 1. Oil and gas; 2. Palm oil and related products; 3. Financial services; 4. Wholesale and retail; 5. Tourism; 6. ICT; 7. Education; 8. Electrical and electronics;[15] 9. Business services; 10. Private healthcare; 11. Agriculture; and 12. Greater Kuala Lumpur(The Economic Planning Unit of Malaysia, 2010, p. 122). In addition, instead of attempting to catch up with the technologically advanced countries, the government of Malaysia continued to compete for FDI "not just against countries in the immediate region, but against those in South America and Eastern Europe"(The Economic Planning Unit of Malaysia, 2010, p. 2).

The Tenth Malaysian Plan and Eleventh Malaysian Plan (2016-2020) also addressed/address SME development, particularly opportunities that come from the AEC scheme. However, there are no mechanisms to support indigenous manufacturing

[13] One of the indicators is innovation index such as Global Innovation Index. In 2018, Malaysia, Thailand, and Indonesia ranked 35th, 44th, and 85th respectively (Cornell University; INSEAD; WIPO, 2018).

[14] The root of the riots was the economic disparities between ethnicities in Malaysia, in particular between the *Bumiputera* and the Chinese Malaysians. These riots were the key economic historical event leading to the future Malaysian high economic growth performance (Jomo, 2004; Ritchie, 2005; Andaya & Andaya, 2001).

[15] There is a lack of concreate planning to support foreign technological learning (The Economic Planning Unit of Malaysia, 2010, p. 131).

technology development (i.e., technology dissemination through triple-helix coordination). The government aims to support MNC and SME partnerships to intensify export promotion (market access) (The Economic Planning Unit of Malaysia, 2015, pp. 8-21), which represents a passive FDI-dependent strategy. Furthermore, the industrial strategy presented in the Tenth Malaysian Plan mostly involves the low-technology industry and service sectors (Table 5).

Table 5. Modern Services Subsectors as Presented on the Eleventh Malaysia Plan

Sub-sector	Description
Halal Industry	Develop halal industry by linking Malaysian halal standards to international standards and promote the alternative ingredients industry.
Islamic Finance	Reinforce Malaysia's position as a global Islamic finance marketplace through innovative Islamic financial products and services.
ICT	Improve exports of ICT products and services by developing ICT technology focus areas, infusing ICT in other sectors and strengthening ICT industry support ecosystem.
Oil & Gas Services	Develop Malaysia as an oil and gas hub in the Asia Pacific region through strengthening upstream capability and improve collaboration between industry and higher learning institutions.
Private Healthcare	Grow healthcare travel through international accreditation, increased insurance coverage, and leverage regional referral network.
Private Higher Education	Continue to develop reputable and high-quality private higher education institutions through ratings and quality assessments and self-regulation incentives.
Ecotourism	Position Malaysia as a premier ecotourism destination by leveraging biodiversity assets and increased branding and promotion.
Professional Services	Promote Malaysia as an outsourcing center for professional services to increase exports through capacity building.

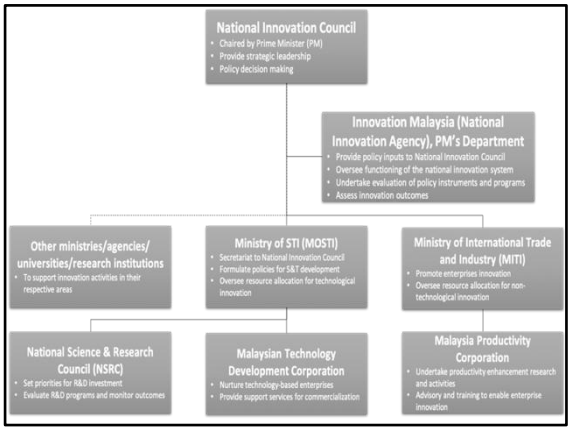
Source: (The Economic Planning Unit of Malaysia, 2015, pp. 8-19)

Prior to the government change in 2018, the Ministry of Science, Technology, and Innovation (MOSTI) was the main agent responsible for the national STI policy (Fig. 7). Based on the National Policy on Science, Technology, and Innovation (Ministry of Science, Technology, and Innovation of Malaysia, 2016) and the Strategic Plan of the Ministry of Science, Technology, and Innovation 2016-2020 (Ministry of Science, Technology, and Innovation of Malaysia, 2017), the National Science Research Council mostly prioritized a resource-centric sector (Fig. 8) (Ministry of Science, Technology, and Innovation of Malaysia, 2017, p. 9). MOSTI transformed into MESTECC in 2018 when Mahathir returned to Malaysian politic as its seventh prime minister. They renewed their national economic strategy[16] in the Mid-Term Review of the Eleventh Malaysia Plan 2016-2020: New Priorities and Emphases (The Economic Planning Unit of Malaysia, 2018). However, there is no trace of a mechanism to support indigenous manufacturing technology development within its five main elements, which were developed "to move up the value chain"(The Economic Planning Unit of Malaysia, 2018, p. 19)

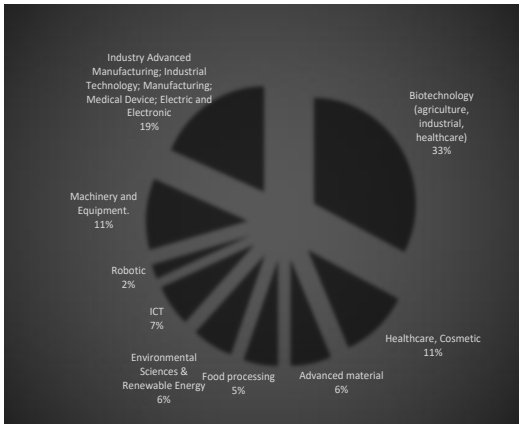
Figure 7. Institutional Structure Supporting Innovation and R&D Activities in Malaysia before 2018

Figure 8. Projects Funded by the Malaysian Technology Development Corporation Categorized by Its Technology Clusters 2016-2018

[16] Due to the corruption 1Malaysia Development Berhad (1MDB) scandal involving the incumbent political coalitions, the revised Eleventh Malaysia Plan emphasizes government (public sector) transparency. In 2015, news broke that about US$ 700 million was allegedly moved from the 1MDB project into Prime Minister Najib's personal bank account (Reuters, 2018).



Source: (The Economic Planning Unit of Malaysia, 2010, p. 85)



Source: (Portal Data Terbuka Malaysia, Goverment of Malaysia, 2018)

The National Policy on Industry 4.0, released in 2018, does acknowledge the challenges of AEC's GVC expansion scheme for the indigenous manufacturing sector, which contains 98.5 percent SMEs (Ministry of International Trade and Industry of Malaysia, 2018, pp. 27-28). The policy's strategy is called F.I.R.S.T (i.e., Funding, Infrastructure, Regulations, Skills and Talent, and Technology). MESTECC is mainly responsible for Malaysia's technology strategy (Ministry of International Trade and Industry of Malaysia, 2018, p. 66). However, MESTECC priorities consist mostly of green technology, energy efficiency, and environmental issues (Table 6). Meanwhile, the electrical and electronic equipment is the sector with the highest share of value added in ASEAN (see Fig 3) and employs 25 percent of the Malaysian manufacturing sector workforce (Ministry of International Trade and Industry of Malaysia, 2018, p. 25).

Table 6. MESTECC's Focusses

1. Green and Efficient Energy Sector	□ To increase the percentage from 2% to 20% of renewable energy for electricity generation □ To improve the national energy efficiency □ To improve the efficiency and transparency of the energy market to ensure the best tariffs for energy consumers
2. Environmental Pollution-free and Resistance to Climate Change	□ Leading the country towards a free non-biodegradable plastic □ To reduce pollution through education and enforcement □ To prepare country to address climate change through adaptation and mitigation
3. Wealth Creation Through Science and Technology	□ Demand-driven R&D through close collaboration with the industry □ To increase technology commercialization into marketplace □ To increase industrial productivity through science & technology applications

Source: (Ministry of Energy, Science, Technology, Environment, and Climate Change of Malaysia, 2019a)

MESTECC offers two types of R&D funding schemes. The first scheme is for SMEs and is called the MESTECC R&D Fund. This fund prioritizes three research areas: (1) Water, Food, and Energy; (2) Green Growth for Sustainable Development; and (3) Medical and Healthcare (Ministry of Energy, Science, Technology, Environment, and Climate Change of Malaysia, 2019b). The second scheme is the International Collaboration Fund (for Government Research Institutions, Government STI Agencies, and Public and Private Institutions of Higher Learning (IHLs) with accredited research programs), which prioritizes five research areas: (1) Biotechnology; (2) Engineering and Technology; (3) Computer Science and ICT; (4) Medical and Health Sciences; and (5) Agriculture and Forestry (Ministry of Energy, Science, Technology, Environment, and Climate Change of Malaysia, 2018). Overall, the Malaysian national STI policy still bounded to natural-resource technology development instead of prioritizing indigenous manufacturing technology development as part of an industrial catch-up strategy.

b.Thailand: Agriculture-Oriented National STI Policy

Since Thailand's inception as a modern state in 1932, the agricultural sector has played an important part in Thailand's economy due to its political clout.[17] The Thaksin administration (2001-2006) represented the first and only period in which the government of Thailand pursued industrial catch-up under a long-term industrial policy. Thaksin ultimately failed to build a broad political coalition to support his policy (Doner, et al., 2009; Intarakumnerd, 2011). After his administration ended, the government of Thailand constructed a national economic strategy around a self-sufficiency philosophy,[18] in which the national STI policy sought to develop agriculture, energy and resource efficiency, and a green economy. Thailand continued to rely mostly on technology lending, as the majority of its workforce was still in low-technology sectors and mostly the agricultural sector (ADB, 2015, p. 19).

Since 2007, four volumes of the National Economic and Social Development Plan (NESDP)[19] have placed a high priority on the agricultural development sector. It often emphasized that global environmental problems threaten their agricultural products, food security, and energy security (The Office of the National Economic and Social Development Board of Thailand, 2012, p. ii). The Twelfth NESDP (2017-2021) stated that the first sectoral priority of the national research agenda was food, agriculture, and the biotechnological industry (The Office of the National Economic and Social Development Board of Thailand, 2017, p. 18). The National Strategy 2018-2037 also re-confirms that the government of Thailand aims to increase national competitiveness through strategies based on agricultural value-added exploration, tourism diversification, and resource-based development (The Office of the National Economic and Social Development Board of Thailand, 2018, pp. 6-7).The eleventh NESDP states that in the wake of AEC, "the first priority for Thailand is to develop human resources, especially by upgrading education, linguistic, and labor skills"[20] in addition to stating that "environmental management at the regional level will lead to a more sustainable use of natural resources in the region" (The Office of the National Economic and Social Development Board of Thailand, 2012, p. 4). Furthermore, the government of Thailand also seeks to "promote Thailand as a center for food processing within the forthcoming ASEAN Economic Community"[21] (The Office of the National Economic and Social Development Board of Thailand, 2012, p. 64). Thailand's concern over agricultural sector competitiveness led to their concern over increasing competition from countries such as Cambodia, Laos, Myanmar, and Vietnam due to increasing liberalization under the AEC (The Office of the National Economic and Social Development Board of Thailand, 2017, p. 30).

The National Science, Technology, and Innovation Policy and Plan 2012-2021 states that there are two main sectoral priorities: biotechnology and nanotechnology. Upon a closer look, the main goals of these two sectoral priorities are to support sufficiency in agriculture, resource efficiency, health, and environmental protection (National Science, Technology, and Innovation Policy Office of Thailand, 2019). The majority of the STI projects reported by the National Science and Technology Development Agency of Thailand in 2017 were natural resource-centric technology development projects (Table 7). In 2018, the government of Thailand released Thailand 4.0 as their national strategy to "unlock the country from a

[17]See Hewison (1989) and Phongpaichit and Baker (1995).
[18] It was initiated as a strategy to cope with the aftermath of the 1997/98 Asian Financial Crisis.
[19] This paper investigates the tenth (2007), eleventh (2012), and twelfth (2017) National Economic and Social Development Plans.
[20] One of their missions is to prepare Thailand's workers for entering the ASEAN labor market (The Office of the National Economic and Social Development Board of Thailand, 2012, p. 97).
[21] In this regard, the government of Thailand seeks "to deal with fluctuation in price for agricultural products and to cope with shortages in energy and agricultural products due to the free flow of goods," which requires public-private cooperation (The Office of the National Economic and Social Development Board of Thailand, 2012, p. 97).

middle-income trap" and "advance the country towards the first work country within the context of the 4th industrial revolution" (Ministry of Foreign Affairs of Thailand, 2018). However, the focus of the government of Thailand is more on digitalization and ICT (e.g., smart farming) instead of on developing indigenous manufacturing technology (Table 8).

Table 7. STI Projects in 2017 as Reported by NTSDA

Categories	Programs (Outputs)
Smart Farm	nutritious and anti-oxidant rich Riceberry, flash-flooding tolerant Homcholasit rice for the community, diagnostic kits for shrimp diseases to minimize risk and increase farmers' income, and Agri-Map: a tool for agricultural management.
Smart Food	Dezigner-8: an innovative delivery system to enhance egg quality, low-fat frankfurter, and Active PAKTM fresh produce packaging.
Smart Health	Dentii Scan: a scanner for dental and maxillofacial structures, safety-enhanced ambulance cabin to save lives and medical equipment, and Thai School Lunch to help schools prepare lunch menus to meet nutritional requirements and available budget.
Smart Energy	nanomaterial coating and coating technique to enhance solar thermal energy efficiency.
Smart Industry	NETPIE: a platform to facilitate interconnecting IoT devices, and ENZease: a duo-activity enzyme for one-step biodesizing and bioscouring process of cotton fabric, 100% replacement of chemicals.
Organization	Agricultural Technology and Innovation Management Institute (AGRITEC), was founded under NSTDA, to facilitate the transfer of technologies to farmers. AGRITEC now works with 220 communities in 45 provinces, covering 36 key technologies. Some outstanding projects include organic rice cultivation in Yasothon province and greenhouse technology with photo selective plastic covering.

Source: (The National Science Technology Development Agency of Thailand, 2018, p. 8)

Table 8.Selected Agendas of Thailand 4.0 and Its Targets Related to Industrial and STI Development and ASEAN Economic Community

Agenda 2. Development of Technology Cluster and Future Industries	**5 Groups of Technology and Targeted Industries:** (1) Food, Agriculture and Bio-Tech (2) Health, Wellness and Biomedical (3) Smart Devices and Robotics – Mechatronics (4) Digital, Internet of Things (loT), Artificial Intelligence and Embedded Technology (5) Creativity, Culture and High-Value Services
Agenda 3. Incubate Entrepreneurs and Develop Networks of Innovation-Driven Enterprise	1. A shift from traditional farmers to" Smart Farmer" 2. A transformation of traditional SMEs into "Smart SMEs" 3. A switch from traditional services to "High Value Services" 4. Startup development promotion
Agenda 4. Strengthening the Internal Economy through the Mechanisms of 18 Provincial Clusters and 76 Provinces	**18 Provincial Clusters:** ○ Upper Northern Region 1: Creative Cluster and Agricultural and Food Innopolis ○ Upper Northern Region 2: Gateway to GMS and ASEAN+3 and Green Tourism Destination ○ Lower Northern Region 1: Indo-China Trade and Service Center and Gateway to Myanmar ○ Lower Northern Region 2: Rice Business Center and Heritage Tourism Destination ○ Upper Northeastern Region 1: GMS Trading Center and Gateway to Eastern ASEAN & China ○ Upper Northeastern Region 2: Agricultural and Livestock Center and Northeastern Green Tourism Destination ○ Middle Northeastern Region: Northeastern Agricultural Food Innopolis and Logistics Hub ○ Lower Northeastern Region 1: Khmer Civilization and Sport Creative Cluster and Agricultural Trading Center ○ Lower Northeastern Region 2: World Jasmine Rice Production Center and Gateway to Eastern ASEAN ○ Upper Central Region 1: Cultural Heritage Tourism Hub and Food Innopolis ○ Upper Central Region 2: Organic Food Production Base ○ Middle Central Region: Green Industry Hub, Green Tourism, and Gateway to ASEAN & Global ○ Lower Central Region 1: Western Creative Tourism and Trade Destination ○ Lower Central Region 2: Seafood and Agricultural Trade Center and Global Tourism Destination ○ Eastern Region: Organic Fruits & Clean Industry, and Medical Tourism Destination ○ Southern Region (Gulf of Thailand): Southern Agricultural Trading Center (Rubber, Oil Palm, Fruits) ○ Southern Region (Andaman Coast): World Class Tourism, and Creative Cluster – City of Gastronomy ○ Southern Border Region: Agricultural and Food Innopolis (Rubber, Fishery, Halal Food) **5 Innovation Hub:** ⇒Innovation Hub for Agriculture and Food ⇒Innovation Hub for Aging Society ⇒Development of a Smart City ⇒Innovation Hub for Smart Energy ⇒Creative Hub for Creative Economy

Source: (Royal Thai Embassy, Washington D.C. , 2019)

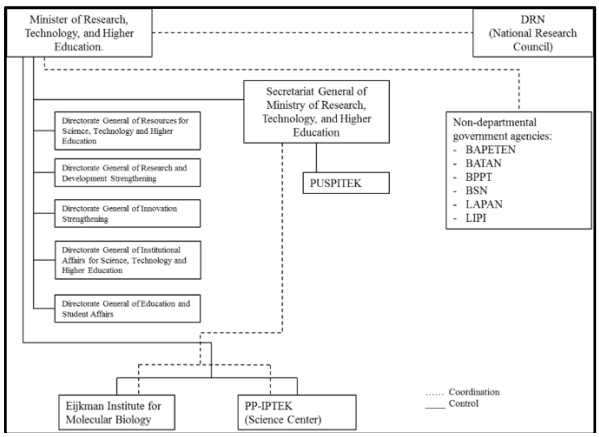
c. Indonesia: The Agrarian and Maritime Competitive Advantage

The agricultural sector has always been at the center of Indonesia's national development strategy. In addition to the agricultural sector, as an archipelago country, Indonesia also pays extra attention to their maritime sector (e.g., fisheries, maritime security). After the 1997/98 Asian Financial Crisis, the government of Indonesia adopted a pro-poor approach by prioritizing the agricultural sector. The agricultural and maritime sectors hold important positions within the Indonesian STI policy, upon which the New Order era (1966-1998) left a strong legacy. A combination of these two sectors also extends into how the government perceives the AEC challenges, which amounts to a reaction fairly similar to Thailand's.

Since 2004, the Indonesian government have been promoting resource-based economic planning to pursue a "Maritime and Agrarian Competitive Advantage," as stated in the 2005-2025 Long-Term National Development Plan(Ministry of National Development Planning of the Republic of Indonesia, 2005). President Joko Widodo, since 2014, has constructed the *Nawa Cita* strategy using the same main idea. The *Nawa Cita* strategy, as presented in the 2015-2019 Medium-Term National Development Plan, prioritizes agro-industry, wood and forestry, fisheries, and mining in order to accelerate national economic growth (Ministry of National Development Planning of the Republic of Indonesia, 2014a).With a maritime and agrarian focus, the Indonesian government emphasized the danger of a mass flow of foreign products into the Indonesian market when the AEC went into effect in 2016 harming local producers, particularly the agricultural sector and SMEs (Ministry of National Development Planning of the Republic of Indonesia, 2014b, p. 5.6). The government of Indonesia sought to push for Indonesian leadership in the regional maritime sector and connectivity (e.g., maritime security, maritime resources, maritime food security, maritime tourism, fisheries) (Ministry of National Development Planning of the Republic of Indonesia, 2014b, pp. 5.27-2.28).

In 2018, the Ministry of Industry release a new national industrial strategy called "Making Indonesia 4.0." The ministry aims to promotes five main sectors: (1) Food and Beverages; (2) Textile and Clothes; (3) Automotive; (4) Chemical; and (5) Electronics. This short document shows that the government of Indonesia still continues to rely on MNCs (i.e., by offering tax incentives) to drive the medium-technology manufacturing sectors (i.e., automotive and electronics) (Ministry of Industry of the Republic of Indonesia, 2018, p. 7). Instead of aiming to be a champion for higher manufacturing sectors, the documents states that the government seeks to transform Indonesia into a powerhouse food and beverages industry in ASEAN and a world-class clothing producer (Ministry of Industry of the Republic of Indonesia, 2018, pp. 4-5). The industry 4.0. document discusses mostly digitalization and the implementation of industry 4.0. technologies instead of indigenous manufacturing technology development.

Figure 9. Current Key STI Policy Agents in Indonesia



Notes: This figure is author's modification from Bishry and Hidayat (1998, p. 10) with adjustment based on (Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2016a, p. 24)
Source: author

Table 9. Indonesian National Research Priority Agenda (2015-2044)

Research Area	Priority Rank Based on Development Period					
	2015-2019	2020-2024	2025-2030	2030-2034	2035-2039	2040-2044
Natural resource-based technology	**1**	6	5	4	3	2
Natural resource-based advance technology	2	**1**	6	5	4	3
Applied technology in manufacture	3	2	**1**	6	5	4
Applied technology in services	4	3	2	**1**	6	5
High technology	5	4	3	2	**1**	6
Frontier technology	6	5	4	3	2	**1**

Notes: This priority rank refers to government's budget allocation (from first to sixth as follows: 40 per cent, 20 per cent, 15 per cent, 12.5 per cent, 7.5 per cent, and 5 per cent).
Source: National Research Plan 2015-2045 Version 3.5.2. (Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2016a, p. 34)

It is important to acknowledge the legacy of the New Order era (1966-1998) within their STI policy, particularly in terms of strategic-defense technology. It gave birth to key STI policy agents in Indonesia (Fig. 8) such as the National Research Council and other STI development agencies[22] (Bishry & Hidayat, 1998; Amir, 2013). Under B.J. Habibie's leadership, Indonesian science and technology policies pursued high-technology development, particularly aircraft development. After a regime change in 1998, and due to the impact of 1997/1998 Asian Financial Crisis on the domestic economy, the government of Indonesia ceased to pursue high-technology development and re-oriented the STI policy towards supporting agricultural technology development (Ministry of National Development Planning of the Republic of Indonesia, 2008). The STI agents from the New Order remained as key STI agents (Fig. 9).

The National Research Plan 2015-2045 states that there are seven priority fields[23]on the Indonesian National Research and Technology Agenda: (1) Food Security; (2) Energy and New Energy; (3) Health and Medicine; (4) Transportation; (5) ICT; (6) Defense and Security Technology; and (7) Advanced Materials (Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2016a, p. 39). Table 9 shows that the prioritization of resource-based industries continues. The National Research Plan 2015-2045, in particular, emphasizes the food and pharmacy industries, cosmetics, and the health equipment industry as priority industries that need support from technology development(Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2016a, p. 26).

The prioritization of resource-based technology development is also manifested in various STI policy programs implemented by the Ministry of Research, Technology, and Higher Education of the Republic of Indonesia. The Ministry's annual reports in 2015 and 2016 provided lists of regular STI policy programs and projects, which included a National Science and Technology Park (N-STP), Regional Innovation Cluster (RIC), Technology Business Incubator (TBI), and university-based Centers of Excellence (COEs).[24] Most of the N-STP units, which are owned and operated by the Ministry of Research, Technology, and Higher Education, conduct resource-based product development (e.g. *sago,* wood, coffee, fisheries). Various innovation clusters under RIC also deal with low-technology products (e.g., brown sugar, bananas, sweet potatoes, fisheries, crafts and woven products). The TBI program outputs presented on the two annual reports show that it mostly aims to increase resource-based industry production capacities instead ofupgrading manufacturing (e.g., seaweed technology, electric stoves for Batik textiles, milk pasteurization, green bean technology, rice technology). Since 2014, out of a total of 45 COEs, only two units are conducting R&D in medium-technology development (i.e., automotive and electronics), and Bogor Agricultural University controls the majority of the COEs.The 2016 Performance Report of the Ministry of Research, Technology, and Higher Education provides a list of 45 industrial prototypes developed by various STI agents in Indonesia since 2014(Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2016b, pp. 121-124).Based on the list of industrial prototypes provided by the 2016 Performance Report of the Ministry of Research, Technology, and Higher Education, numerous industrial prototypes have been developed for strategic-defense purposes, including maritime radar, a water cannon, and an infrared

[22] These agencies are Agency for the Assessment and Application of Technology (BPPT), Indonesian Institute of Sciences (LIPI), National Institute of Aeronautics and Space (LAPAN), National Nuclear Energy Agency of Indonesia (BATAN), Nuclear Energy Regulatory Agency (BAPETEN), Indonesian Aerospace.

[23] The 2017 version of this document included a maritime research, which mostly aims to develop a maritime economy, such as fisheries, bio-technology maritime, tourism, ships. (Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2017, pp. 73,76, 82).

[24] Indonesia is the initiator of the Technology Business Incubator program within ASEAN's STI development scheme for SMEs.

rocket(Ministry of Research Technology and Higher Education of the Republic of Indonesia, 2016b, pp. 128-152).

d. Summarizing the National STI Policies of Malaysia, Thailand, and Indonesia Under the AEC Regime

The AEC does not automatically translate into the pursuit of industrial catch-up. At in the case of these three middle-income ASEAN countries, their competitors are other latecomer countries (e.g., other ASEAN member countries) instead of advanced countries (e.g., ASEAN's external partners). A deeper examination of national STI policies shows that the national governments understand the importance of technology development by STI agents; however, as natural resource-abundance countries, their national STI policies do not reflect the idea of upgrading indigenous manufacturing subsectors. The national STI policies of Malaysia, Thailand, and Indonesia have always been intertwined tightly with natural resource-based technology development (e.g., agricultural development, energy efficiency). In the era of industry 4.0., the governments in these three countries have focused on digitalization and the implementation of industry 4.0. technologies instead of indigenous manufacturing technology development. The AEC (i.e., global production network expansion) does not induce any sense of strong urgency for these three middle-income ASEAN countries to alter their national STI policy directions and objectives (i.e., they are remaining path-dependent). Thus, these governments will be likely to continue to implement passive, FDI-dependent strategies.

Table 10. Summary of Malaysia, Thailand, and Indonesia

	Malaysia	**Thailand**	**Indonesia**
How the national development plan captures challenges from AEC	Opportunities for manufacturing SMEs (but lack of exploration of the mechanism for indigenous manufacturing technology)	Challenges for labor, increasing challenge for agricultural sector in terms of competitiveness from CLMV countries	Challenges for labor, domestic market, investment and financial sectors, maritime sector
The STI priorities since AEC 2007	Agricultural modernization, bio-technology, health, ICT, climate, and green growth	Biotechnology and nanotechnology, with the main objective of enhancing the agricultural sector, environmental conservation, energy security	Agricultural technology, food sector, maritime technology, strategic-defense

Source: Author

Closing Remarks: Missing Opportunities and the Lack of Urgency

As scholars demand efficient government policies (i.e., to increase indigenous technological capabilities as the foundation for structural transformation), they often neglect to realize that the national governments of these latecomer countries have different mindsets on how certain policies should function (i.e.,the path-dependence problem). There is a problem with assuming that all national governments are rational economic actors that will strategize to help the most effective sector (i.e., the manufacturing sector). The case of the three middle-income ASEAN countries shows that "opportunity maximization" is not a strong enough motive to push national governments to alter their national STI policy directions. If scholars seek to place governments as the central actors in latecomer countries, then the largest obstacle for these resource-abundant, middle-income countries in terms of altering their economic development paths is the difficulty to alter the national strategy from resource-

based strategies to technology-based strategies.With regards to ASEAN,the urgency in terms of pursuing industrial catch-up, both at the national level and collectively as a region, toshore up weak technological capabilities must be emphasized.

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