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Industry 4.0 Policies in Thailand

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Abstract

The Thai government has implemented a number of policies to harness the potential of the fourth industrial revolution (Industry 4.0). These policies can be categorized into three broad categories, namely, digital infrastructure, skill formation, and target industries. As is often observed for other policies in Thailand, the policy coverage for Industry 4.0 is too broad. Many aspects are included without a clear prioritisation. There is no effective mechanism to assess these policies and their implementation largely depends on government agencies' preferences. The existing assessment mechanism induces these agencies to undertake easy-to-achieve activities such as training. Activities that are critical for building a solid foundation to harness the potential of Industry 4.0 are unlikely to be implemented. The government has expressed interests in e-activities such as the provision of support for e-commerce platforms and social media applications. A more stringent cyber security law could be counter-productive and jeopardize business opportunities emerging from Industry 4.0.

Keywords: Industry 4.0, Industrial Policy, Manufacturing

JEL Classification: L60, O25, O38

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1. Introduction

Industry 4.0 is a term given to the current trends in automation and data exchange technologies in manufacturing and services. The term was used in Germany to describe the digital transformation of manufacturing. Different names have been used alternatively, e.g. Industrial Internet of Things (Kiel et al. 2017), Fourth Industrial Revolution (Schwab, 2016) and Second Machine Age (Brynjolfsson and McAfee, 2014). These terms refer to the integration of Internet of Things (IoT) technologies into industrial value creation which enables manufacturers to harness entirely digitized, connected, smart and decentralized value chains. This has a profound impact on the way of doing business and society (Porter and Heppelman, 2014; Schwab, 2016; Klingenberg and Antunes, 2017).

As in other countries, the government of Thailand has formulated a number of industrial policies to make use of new technologies associated with Industry 4.0. The goal of this study is describe and critically assess the Industry 4.0 policies in Thailand. These policies range from industrial policies for structural transformation, incentives and support for ICT adoption, programmes to re-skill and re-train workers and the state of e-government.

The outline of this study is as follows. Section 2 provides a broad discussion of the nature of Industry 4.0. The industrial policies for structural transformation of manufacturing is examined in Section 3. The government's policies to enhance ICT adoption is discussed in Section 4. The re-skilling of workers are discussed in Section 5 whilst Section 6 looks at e-government. Section 7 concludes.

2. The Nature of Industry 4.0

The concept of Industry 4.0 has four components. The first component is cloud computing which involves the delivery of hosted services over the Internet. These services are broadly divided into three categories: Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS) and Software-as-a-Service (SaaS). The presence of cloud computing makes computer system resources, especially storage and computing power, available on demand without direct active management by the user. The term is generally used to describe data centers available to many users over the Internet. Large clouds, currently, have functions distributed over multiple locations from central servers and by many users. It can be private or

public. This could save IT infrastructure costs for firms as they can get their applications up and running faster, with improved manageability and less maintenance. It also enables IT teams to adjust resources more rapidly to meet fluctuating and unpredictable demand.

The second component is internet of things (IoT). IoT revolves around altering how machines communicate with each other. In the past, machines were physically linked with one another. With IoT, a machine can communicate with other machines through censors. This enables a machine to gather data from other machines and evaluate them. The value of IoT is greatly enhanced when it is built on cloud computing and networks of data-gathering sensors. Cloud computing infrastructure makes it possible for data exchanges between censors to be analyzed and transmitted in real time, thus enabling users to access such services anytime and anywhere[1].

Cyber-physical system (CPS) is the third component. It is a mechanism that is controlled or monitored by computer-based algorithms and is tightly integrated with the Internet and its users in such a way that the physical and software components are deeply intertwined. Each CPS operates on different spatial and temporal scales, exhibiting multiple and distinct behavioral modalities, and interacting with each other in a variety of ways that change with context. Examples of CPS include autonomous automobile systems, medical monitoring, process control systems, robotics systems, and automatic pilot avionics. Under CPS, the process control (often referred to as embedded system) tends to focus more on computational elements, and less on an intense link between the computational and physical elements. The main difference between CPS and IoT is that the former involves a higher combination and coordination between physical and computational elements as opposed to the latter.

The last component is cognitive computing (CC), regarded as technology platforms are based on the scientific disciplines of artificial intelligence and signal processing. These platforms encompass machine learning, reasoning, natural language processing, speech recognition and vision (object recognition), human–computer interaction, dialog and narrative generation, among other technologies. The phrase cognitive computing implies a computer with eyes and a brain. Cognitive computing can potentially replace humans for repetitive tasks and facilitate enormously our daily life. Indeed, computers might not possess cognitive abilities, but they are capable of executing operations which completely rely on human perceptions. It is always possible to use the power of automation: from handwriting

[1] Please see Burrus (2014) for some examples of IoT use.

recognition, face identification and behavioral pattern determination to any task requiring cognitive skills, computers are capable of delivering the right solutions.

As a result, smart factory is created, where machines, devices, sensors, and people are connected and communicate with each other in real-time. This takes place internally and across organizational services offered and used by participants of the value chain. Industry 4.0 technology provides operators with vast amounts of useful information needed to make appropriate decisions. Inter-connectivity allows operators to collect immense amounts of data and information from all points in the manufacturing process, thus aiding functionality and identifying key areas that can benefit from innovation and improvement. (Hermann et al., 2016).

The effect of Industry 4.0 on the productivity of firms in developed countries is clearly positive as automation has been well in place for some time. Hence, Industry 4.0 makes the automation system work even more efficient. This can take place in various forms such as lowering production breakdown, lowering product defects caused by human error, and enhancing flexibility. In addition, business decisions can be made based on indepth insights and real time data as analog data are digitized, and transmitted to the top management staff at a much faster speed. All in all, it enhances the business competitiveness of factories in developed countries. One clear example was revealed in Economist (2015) in the form of the presence of robotic sewing machine in the United States and their effects on garment workers in low-cost countries.

By contrast, the effects of automation is rather complicated for developing countries. To the best of our knowledge so far, there has not been any systematic analysis of the effects of Industry 4.0 automation on developing countries.[2] It might be possible to make a conjecture on such effects. This defines the scope of our analysis in this study. Firms in developing countries are facing more intense competition as factories in developed countries become smarter and business decisions are based on depth-of-insight and real-time data. Such firms can potentially enhance productivity by making greater use of digital technology transformation, e.g. automation, depth-of-insight and real-time data (big data and data analytics), and e-government. New business opportunities are created as a result of the digitalization revolution. However, such opportunities are associated with various forms of threats including cyber security, privacy violation, and job replacement.

[2] This is also reflected in the survey by Goldfarb and Tucker (2019)

3. Industrial Transformation in Thailand

Many countries have embarked on formulating and implementing Industry 4.0 policies. Similarly, the Thai government has been engaged in formulating Industry 4.0 policies in recent years. In 2016, the government launched *Thailand 4.0* in order to transform the Thai economy into a value-based economy. The policy package is an industrial policy that combines picking-up winners and an economic corridor framework where economic agents are well connected within a defined geography.[3] In the former, ten newly targeted industries were selected with a hope to serve as new and more sustainable growth engines. These ten industries are equally divided into two segments, 5 S-curved and 5 new S-curved industries. The five **S-curved industries** include new-generation automotive, smart electronics, affluent, medical and wellness tourism, agriculture and biotechnology, and food for the future, All but digit industries are connected to the existing industries in Thailand with the hope that the government could attribute to the productivity improvement, and value addition. The **new S-curved industries** are nascent high-tech industries slated to become significant long-term growth drivers. The five new S-curved industries include manufacturing robotics, medical hub, aviation and logistics, biofuels and biochemicals and digital industries (**Figure 1**).

The Eastern Economic Corridor (EEC) - the newest special economic zone - was established to achieve the industrial transformation under Thailand 4.0. The EEC is the flagship industrial development project of the General Prayuth Administration (2014-2019) and is expected to be continued in the current government.[4] The EEC straddles three eastern provinces of Thailand – Chonburi, Rayong, and Chachoengsao – that are located off the coast of the Gulf of Thailand. It covers a total area of 13,285 square kilometers. The government hopes to complete the EEC by 2021, turning these provinces into a hub for technological manufacturing and services with strong connectivity to its ASEAN neighbors by land, sea and air.

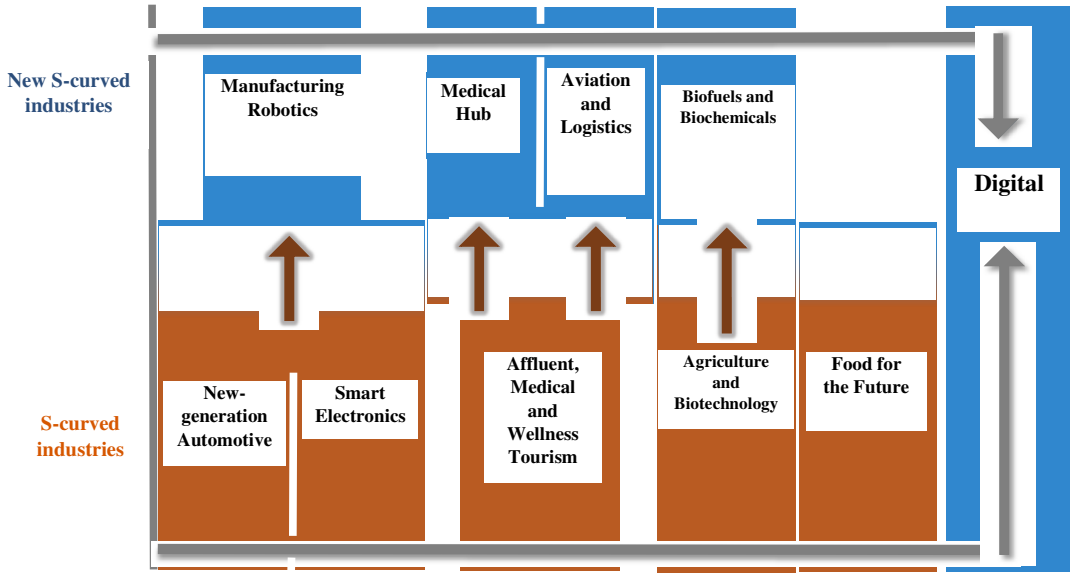
On February 1, 2018, the Thai parliament approved a law for trade and investment in the Eastern Economic Corridor (EEC). It was published in the Government Gazette on 14th May 2018 . The EEC Policy Committee ("EECPC") was established to implement and enforce the EEC, chaired by the Prime Minister. EEC Offices ("EECOs") were set up as one stop service centers in three locations - Bangkok, Laem Chabang Industrial Estate and Map Ta Phut Industrial Estate in Rayong - to handle applications for permissions and licenses necessary for

[3] See Brunner (2013) for a discussion of the concept of economic corridor.
[4] Bloomberg June 21, 2017 - available at https://www.youtube.com/watch?v=_597uiE5UlI.

business operation in the SEPZ. Thus, the authorities responsible for approving license applications under several laws (i.e. building control law, factory law, etc.) have all been transferred to the EECO to simplify the regulatory processes for foreign investments. The EECO is also establishing an e-permission and privilege system to facilitate applications and approvals online.

Figure 1: Ten Newly Targeted Industries in Thailand 4.0

(5 S-curves and 5 New S-Curves)



Source: EEC Office

To enhance connectivity within as well to EEC, the Thai government has invested heavily on infrastructure to enhance connectivity of these three provinces with the rest of the world. Total infrastructure investment amounting to $43bn of investments will be channelled into the EEC by 2021. These investments will come from state funds, FDI and through infrastructure development under a public-private partnership framework.

Air transport and cargo capacities are also being enhanced substantially through expanding the U-Tapao airport and setting up a maintenance, repair and overhaul (MRO) centre in Rayong province (US$5.6 billion). The Laem Chabang seaport (Laem Chabang Phase 3) – already the country's biggest seaport – will be further expanded with the goal of transforming

it into a marine hub of South East Asia. This could establish sea routes from the eastern provinces of Thailand to Myanmar's on-going Dawei deep-sea port project, Cambodia's Sihanoukville port, and Vietnam's Vung Tau port (US$2.5 billion). The third phase of the Map Ta Phut seaport was also introduced with a total investment of US$ 1.5 billion. The road network will be extended to enhance connectivity with sea and air transport (high-speed train, double-track railways, highways) (US$4.5 billion). High-speed and double-track railways connecting ports, airports, industrial clusters, and major urban centers will be launched to improve connectivity by road. This is associated with improvements of expresways from other provinces (Northeastern, Central, and Bangkok to EEC). Land links to China will also be strengthened via the construction of a new high-speed railway from Bangkok to Kunming. This is to ensure that Thailand is linked with Chinese mega projects associated with the Belt and Road Initiatives.[5]

More investment incentives have also been offered to make EEC competitive. In particular, those who invest in the three provinces of the EEC are now eligible for income tax holidays for up to 15 years, a reduced personal income tax rate of 17 per cent and a 50 per cent reduction in corporate income tax rates over five years, as well as existing exemptions and benefits offered by Board of Investment (BOI), such as access to long-term land leases, import duty exemptions and work visas. Such incentive packages are greater than what the Thai government normally offers to BOI-promoting activities (Jongwanich and Kohpaiboon, 2019). New subsidies will also be rolled out in the form of a B10 billion (US$282 million) seed fund called Industrial Economic Development Fund (IEDF) that will offer special interest rate and investment funds for activities prioritised by the government including R&D and skill formation at Thai universities.

EEC also bypasses regulatory cumbersomes that businesses usually experience. For example, foreign skilled labors, executives and specialists working for businesses in the SEPZ can now work in Thailand without a work permit upon receiving a permit from the Secretary General of EECO. In another example, the authorities to approve license applications under several laws (i.e. building control law, factory law, etc.) have been transferred to the EEC Policy Committee chaired by the Prime Minister. The newly amended Public-Private

[5] Data are from EEC office published in Bangkok Post (2018), '4 EEC projects approved for infrastructure' 5 October, available at https://www.bangkokpost.com/business/1552186/4-eec-projects-approved-for-infrastructure and Roadshow document by M. Sibunruang, Executive Director U-Tapao Airport City Project Management available at https://www.boi.go.th/upload/content/Aviation_BOI%20roadshow_Full%20version_5ab4f81a06c70.pdf

Partnership Act was enacted to streamline and make more transparent the complex regulatory regime in the earlier version of the Act.

Three remarks can be drawn from the policy initiatives discussed above. Firstly, the rationale for the choice of these industries is unclear. Interestingly, seven of the ten industries targeted in Thailand 4.0 overlaps with the ten targeted industries under China's Made-in-China 2030 initiatives. To some extent, many of these industries are not connected to each other. For example, new-generation automotive and smart electronics are planned to be starting points for manufacturing robotics. Medical and wellness tourism are further combined into medical hub.

Secondly, while the effort to target specific industries do signal an ambitious policy effort, the EEC is in practice just a typical policy aimed at enticing FDI from abroad by providing high-quality infrastructure. The implementation plan lacks clarity and pragmatism. Consider the next-generation automotive industry, which is loosely defined as non-internal combustion vehicles but is referred to as electric vehicles in public). The Thai government has set a very ambitious target for the industry. It aims to have 1.2 million EVs and 690 charging stations nationwide by 2036 – about 20 years from the time the plan was launched. To put this goal in perspective, the market share of the internal combustion engine vehicles was about 99.4 per cent in the period 2016-2018. Certain parts of EVs such as battery, safety parts, and transmission system, and engine exceeding 248 cc for motorcycles are targeted. The most important policy tool would be the much lower newly designed excise tax on electric vehicles introduced in 2017. Nonetheless, the eligibility for this incentive is conditioned by the local content requirements on battery.

To a large extent, a similar pattern is observed for the new S-curved industries such as the digital industry. Activities to be promoted included embedded software, e-commerce players, analytics and data center, cloud computing, and cyber security, creating smart cities (connected through internets and referred as IoTs), and creative media and animation. A number of incentives have been granted such as 200 per cent R&D expenditure tax deductions, work permits for professionals and grants to the universities to promote digital activities. At this stage, the overall implementatiton strategy for this industry remains vague

Finally, the challenge of pushing firms to adopt automation has not been systematically addressed. Even though many aspects of the policies promoting EEC have been proposed, policies promoting indigenous firms to make greater use of ICT technologies as well as automation have not been considered as top priority. For example, the National Science and Technology Capability (NSTC) programme offers financial assistance to firms to install automation. It was implemented within a small group of firms as its true policy purpose is to

strengthen indigenous firms in automation system integration instead of adopting the automation system in production line. In addition, the process of firms fully utilizing automation systems takes time and involve risk and uncertainty. As such, it is harder for government agencies in charge to fulfill their key performance index (KPI) from such activities. Hence, it is less likely that this type of assistance will be a top priority for government agencies. A similar circumstance is found in the Big Brother Guarantee Success Solution (SME Scale up) programme introduced by the Department of Industrial Promotion, Ministry of Industry. This programme has multiple objectives, of which business transformation to make a greater use of ICT technologies is one.[6] Other objectives include marketing, creative innovation village (CIV), and process agriculture. The most publicized cases are the creative innovation villages and process agriculture. These projects are mainly implemented for income redistribution and rural development purposes rather than harnessing gains from Industry 4.0.

4. Policies to Enhance ICT Adoption

ICT adoption is a key factor in harnessing the benefits of Industry 4.0. The Thai government has emphasized the importance of ICT since the mid-1990s. ICT has the potential to enhance productivity and promote long-term growth. The first plan at the national level, *Thailand National IT policy (1996-2000)*, was introduced in the mid 1990s. Since then, a number of national-level plans have been launched. These include the Thailand Information and Communication Technology (ICT) Policy Framework (2001-10), the National Broadband Policy (2009), the Information and Communication Technology Policy Framework (2011-2020), the Universal Service Obligation (USO) Master Plan for Provision of Basic Telecommunication Services (2012-14), and more recently, the Digital Thailand Plan (2016).

The Digital Thailand Plan (2016) has five main elements. They are: (i) investing in both hard ICT-related infrastructure (e.g. fixed and mobile infrastructure, reliable networks) and service infrastructure (e.g. single platform), (ii) e-government services (paperless), (iii) soft infrastructure (e.g. cybersecurity, amendment of existing laws and regulations), (iv) digital economy promotion (e.g. e-commerce, software industry, digital marketing), and (v) digital society and knowledge (e.g. universal access by each and every Thai citizen at an affordable price). The key goals of the plan is to enable Thailand to become a digital leader and strengthen

[6] An example is the attempt to link indigenous firms with multinational automotives' CPS (Honda, Toyota, Denso) in 2018. Nonetheless, the outcome of this initiative is unknown as there is no known assessment study that has been published on the subject.

firms' competitiveness. This plan has been positioned as a policy with high importance for the development of the Thai economy and is currently placed under the direct leadership of Thailand's Deputy Prime Minister.

The Ministry of Information and Communication Technology (MICT), established in 2002, was replaced by the Ministry of Digital Economy and Society (MDES) in 2016. MDES is the sole agency with a broad scope that includes implementing all national ICT plans. It is also the governing body for ICT governance in all government agencies. There are three government agencies under MDES, namely, the National Statistical Office, the Meteorological Department, and Post Office. Other state-owned enterprises and public organizations related to ICT activities that are under the jurisdiction of MDES include the Telephone Organization of Thailand (TOT), The Communications Authority of Thailand (CAT), Electronic Government Agency (Public Organization) (EGA), and Electronic Transactions Development Agency (Public Organization) (ETDA).

The Software Industry Promotion Agency (SIPA) was also replaced by Digital Economy Promotion Agency (DEPA) which is currently the workhorse to promote and support the development of digital industry and innovation and the digital technology adoption (see below for further elaboration).[7] The Digital Development for Economy and Society Act B.E. 2560 (A.D. 2017) was promulgated on 23 January 2017. The goal of the Act is to achieve greater economic, social, cultural and security benefits from digital development at the national level. One major policy effort by DEPA is the DEPA Fund. The allocated funds range from 50,000 baht to 250 million baht per firm.

Under the DEPA Fund, there are 4 main measures to promote the use of ICT by firms:

1. ***Digital Startup***: The DEPA Fund provides financial support for startup business. The financial support varies according to the stage of a firm's development. An amount of 50,000 baht per firm is granted to a startup firm for developing a conceptual plan. The grant size can be increased to 1 million baht for a firm to commence operation. The grant is divided into two parts: (i) 300,000 baht is granted to cover costs induced by patent registration or standard certification, and (ii) The Fund covers 70 per cent of the project value but not exceeding 700,000 baht for prototype development. The grant size increases to 5 million baht when an enterprise is expanding. This is divided into two parts. The first part covers 70 per cent of project value but not exceeding 4.3 million

[7] The exception is National Disaster Warning Center,which was formerly under MICT, is to be transferred to the Interior Ministry. In addition, MDES plans to set up a cybersecurity agency and hacker training centre.

baht. The rest is for machines, tools and equipment. The financial support is 70 per cent of the project value but not exceeding 0.7 million baht. When a firm is set up (i.e. grant size increases to 1 million or more), the granted financial support will be turned into equity share. The conversion ratio is 25 and 50 per cent for 1 and 5 million financial support, respectively.

2. ***Digital Transformation***: Financial grants are given to assist firms in adopting ICT in their businesses. Two options are available: (i) The first option is 50,000 baht / an enterprise to develop an action plan to make use of ICTs, (ii) The second option is a financial subsidy for ICT adoption (60 per cent of project value) but no exceeding 1 million baht.
3. ***Digital R&D and Innovation***: Financial incentives are provided to R&D projects related to ICT adoption by firms. Financial support is in terms of equal co-funding (50 per cent of project value).
4. ***Digital Event and Marketing***: Financial support is provided for activities related to promoting ICT usage, business matching, contests, and raising awareness. Financial support is in terms of equal co-funding (50 per cent of project value).

In addition to the measures aimed at assisting firms, there are also policies to promote public use of digital technology such as digital manpower, digital community and digital infrastructure measures. Digital manpower has 2 components. The first component is financial support provided to academic institutes as well as private and public organizations for ICT training. The support is 100 per cent for academic institutes, and 70 per cent for the others. The grant size varies according to the nature of the training courses, ascendingly from digital literacy, digital professional, digital specialist, to highly demanded skills. The grant size is 5,000, 10,000, 15,000 and 100,000 per person, respectively. The second component is for executives to enroll in training courses approved by their own organization that can be provided by either private or public organizations. Three executives per organization is the limit.

Measures of digital community are used to promote activities at the community level. A total of 50,000 baht is granted for the community to develop an activity. To implement the activity developed in the first stage, the grant increased to 500,000 baht a project. The length of the project is less than 3 years. Private and public organization as well as community enterprise are all eligible for the grant.

Digital infrastructure under DEPA is another important policy measure. It is used to facilitate the installation of basic ICT infrastructures by private and public enterprises. To be

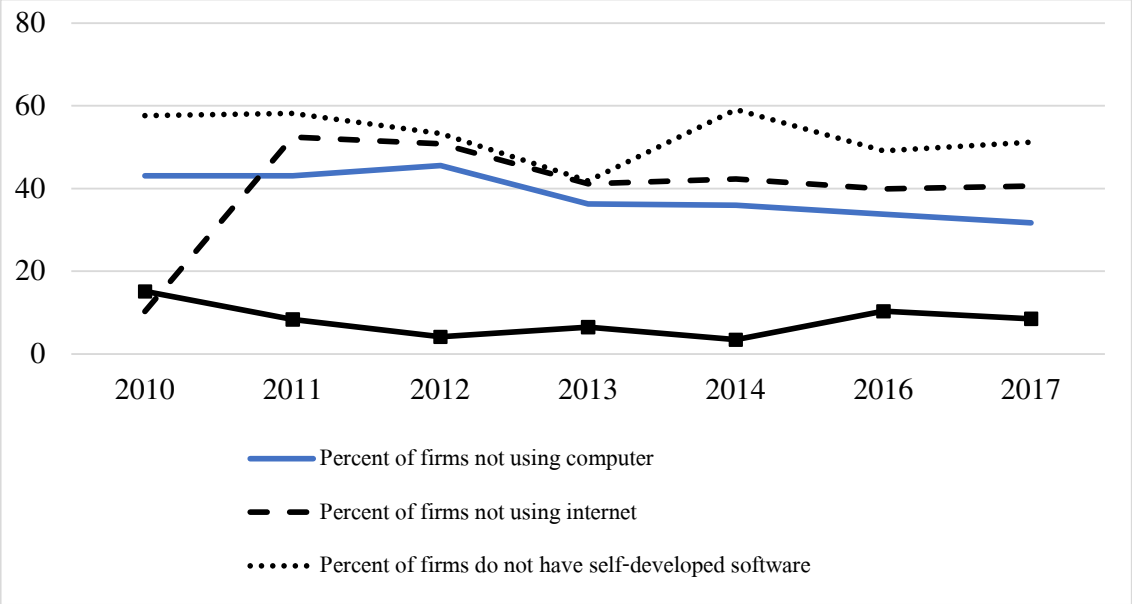
eligible for funding, a project must be work in progress. It includes construction, building, cloud computing and other ICT related infrastructure. For private enterprises, only small and medium enterprises (SMEs) are eligible. The support is in the form of co-financing at 50 per cent of a project's value but not exceeding 50 million baht. For government projects, the grant is much larger. It is separated into two stages. The first stage is worth of 50 million baht for a feasibility study whereas the second stage is for implementation with the maximum support of 200 million baht. The project length is 3 and 5 years for SMEs and government agencies, respectively.

Again, what reviewed above suggests that the national plans for ICT tend to have wide coverage without any clear policy priority as well as without any effective performance measures that can be used to measure progress. This could be problematic as many of policy measures take time to turn potential into reality. It also involves risk and uncertainty. Hence, simple, and easy-to-complete measures such training programs, information dissemination programs will be at the top priorities of government agencies in charge.

It seems that these plans were drafted in one-size-fit-all based on the assumption of homogenous firms. In reality, there is digital divide across firms. Hence, firm consolidation is unavoidable and this will render such one-size-fit all policies ineffective. For example, according to the ICT survey conducted by National Statistic Office (NSO), around 40 per cent of firms in Thailand used computers between 2010 and 2014 (Kohpaiboon, 2019) (**Figure 2** and **Figure 3**). To a large extent, a similar pattern was found for the usage of internet. While these figures are unrealistically low due to the sample coverage problems during the survey, it points to vast differences amongst firms in ICT usage behavior. The survey result from a study by Office of Industrial Economics in 2015 also suggests that such differences exist. Furthermore, the production processes of 60 per cent of the firms surveyed was found to be entirely manual or a combination of computer numerical controlled (CNC) and manual (**Figure 4**). Only five per cent of the firms were fully automated.

Figure 2: ICT Adoption in Thailand - Manufacturing Sector

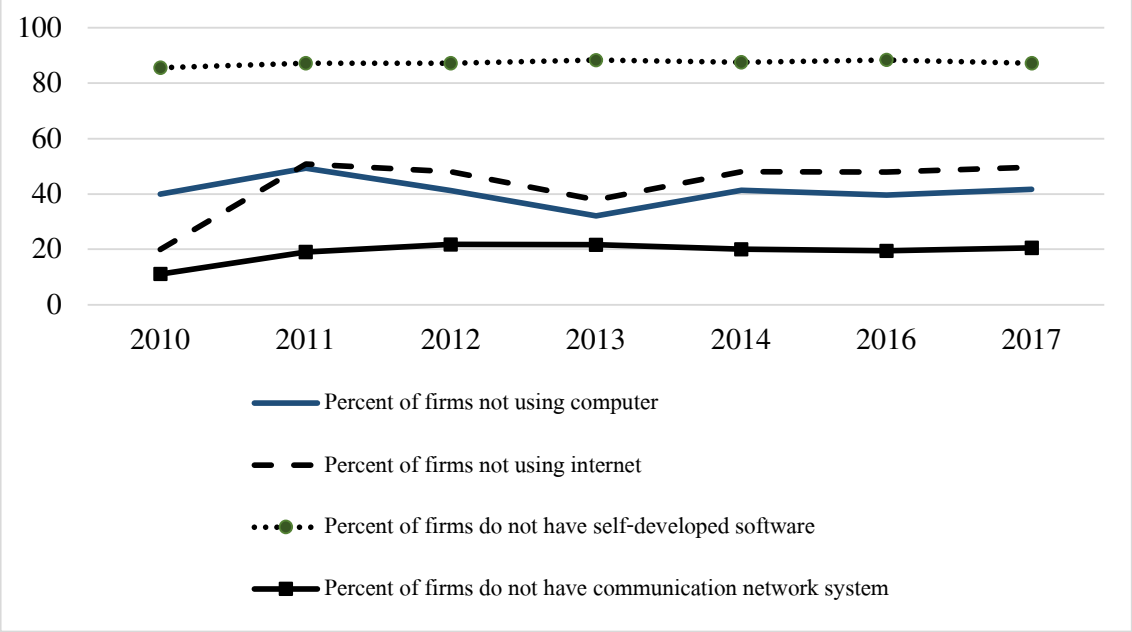
(Percent)



Source: Author's compilation based on ICT Survey conducted by National Statistics Office (NSO)

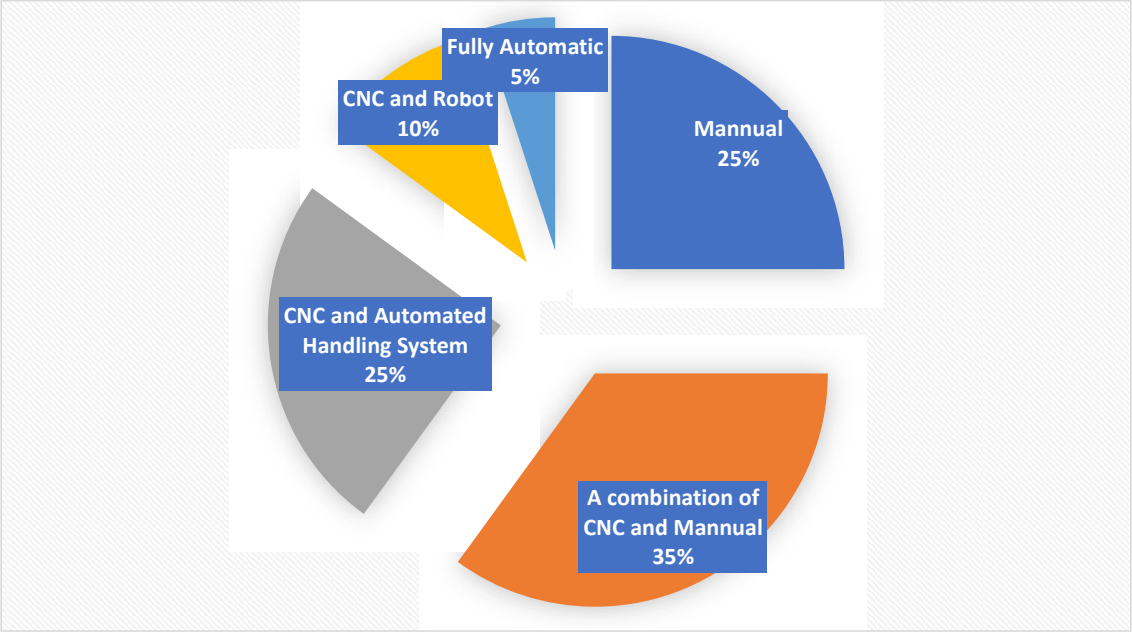
Figure 3: ICT Adoption in Thailand – All Sectors

(Percent)



Source: Author's compilation based on ICT Survey conducted by National Statistics Office (NSO)

Figure 4: The Degree of Automation in the Thai Manufacturing Sector



Source: Office of Industrial Economics (2015)

With respect to cybersecurity, a number of legal and regulatory reforms have been undertaken. The new Cybersecurity Act was introduced in 2019. The reforms' purposes have been overshadowed by the government's action in blocking and controlling the internet instead of focusing on the safety of digital transaction. This topic is clearly beyond the scope of the current paper. The point raised here is the need for better communications between the government and businesses in this area. Otherwise, the government's actions could jeopardize the business environment.

Finally, the Thai government itself has been directly involved in digital transactions. In particular, the Thai government launched an e-commerce platform known as ThaiTrade (www.Thaitrade.com), a government cloud (G-Cloud), and a government mail system (MailGoThai). These are included in the recent digital master plan. The justification for the government role's in these activities remains unclear.

5. Re-Skilling and Re-Training Workers

One implication of Industry 4.0 is that some jobs will be lost because of automation and smarter machines. This is particular true for jobs with repetitive tasks. Policies to re-train workers must be in place to minimize any adverse effects of the industrial revolution. The

Department of Skill Development (DSD), Ministry of Labor is the government agency in charge of policies on the re-training of workers although these have not been addressed systematically including for EEC initiatives. The key policy in skill formation is to train freshly graduated labor force, to improve the ones already in the market, and to add additional skills. In addition, the DSD also provides financial support to establishments to enhance the skills of their workers.

As argued in Kohpaiboon (2019), DSD's own activities covered around 0.5 million workers. The trend for the number of workers covered is decreasing and this was dominated by workers already in the market (60 per cent). The number of workers covered accounts for around 1.3 per cent of total workforce. The types of skill offered by DSD include electricians, plumbers, constructors, service-related. The goal of re-training is not to enhance the productivity of establishments. Instead, re-training is useful for workers that have been retrenched from the current jobs.

The DSD provided financial incentives to firms to undertake skill improving activities. According to the Skill Development Act (2002), all establishments with more than 100 workers must contribute one per cent of total worker compensation to the Skill Development Fund (SDF) managed by the DSD. Alternatively, establishments can undertake their own skill improving activities in which such expenses are regarded as in lieu of contributions to the SDF. Such expenses are also eligible for 200 per cent income tax deductibles (as applied for R&D expenditure). Nonetheless, the incentives have not been very attractive to firms. The per capita expenditure on skill-improving has been small such that it is unlikely to expect any fruitful improvements in workers' skill levels. For example, the expenditure per worker was 848 baht (25$) in 2011 and only 350 baht (15$) in 2013. From 2014 onwards, DSD has altered the program by providing financial lending with a ceiling of one million baht a year.

6. E-Government

Many government agencies in Thailand have attempted to digitise many aspects of their operations such as through implementing e-permission, installing IT equipments (computers and servers), creating digital databases and improving data connectivities. However, as reflected by budget allocations, many of the important areas does not seem to be a top policy priority for the Thai government. These include the installation of IT equipment, the hiring of IT staffs, IT training, installation of mainframe computer, implementation of database system and electronic data interchange system, web development and e-document system This is

evidenced by the fact that the budget allocations in this area have declined between 2015 and 2018, averaging at about 20,000 million baht. Nearly 90 per cent of total expenditures was for hardware such as ICT equipment, mainframe computer, database system. Budget for hiring IT staffs and IT training have been limited although they are important for more efficient use of IT technology(**Table 1**).

Table 1: Thai Government Agencies's Expenditures on IT Equipment

	2015	2016	2017	2018
Total Budgetary Expenditures (Billion Baht)	33.7	18.6	16.6	20.8
(%) Share of total budgetary expenditure				
ICT equipments	90.71	93.57	87.99	86.45
Hiring IT staffs and IT training expenditure	0.00	0.00	0.00	0.00
Installing mainframe computer, database system and electronic data interchange system	8.21	5.27	10.38	11.27
Web development	0.83	0.93	1.32	1.55
E-document system	0.24	0.22	0.31	0.73

Source: Jongwanich and Kohpaiboon (2019) based on the results of using programming interface and text mining

7. Conclusions and Challenges

The Thai government has formulated a number of policies to harness the potential of Industry 4.0. The analytical framework developed in this study points to four areas of policies that need to be assessed, namely, industrial transformation, ICT Adoption, re-skilling and E-government. The key finding is that the policies that have been introduced have not helped position the private sector to unleash potential from Industry 4.0. While infrastructure development in the EEC could be beneficial to enhancing firms' productivity levels, it is unlikely to improve the engagement with Industry 4.0 technologies. Interestingly, some active government interventions are often observed in terms of the picking of winner in the Thailand 4.0 policy.

The Thai government's policies on Industry 4.0 have been very broad in which many areas have been included but without any clear prioritisation amongst them. There is no effective mechanism to assess these policies and their implementation depends largely on

government agencies' preferences. The existing assessment mechanism which focuses on one-year-long performance index induces these government agencies to undertake easy-to-achieve activities such as training and physical infrastructure investment. Activities that are critical to lay down a solid foundation to harness the potential of Industry 4.0 are unlikely to be implemented.

The government has expressed interests in e-activities such as the provision of support for e-commerce platforms and social media applications. Together with the stringent cyber security law, this could be counter-productive and jeopardize business opportunities emerging from Industry 4.0. The private sector moves independently. Performance in terms of readiness for Industry 4.0 suggests substantial digital divide . The re-setting of public policy priorities is needed. The government needs to go beyond one size fit all approaches (due to firm heterogeneity) and put in place better monitoring systems.

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