Augmenting competitiveness with high-road industrial policy: different perspectives from Asian middle-income countries

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This paper conceptualises and evidences incidences in which middle-income countries practicably augment competitiveness with high-road industrial policy, embracing strategies for generating structural transformation with innovation-driven economic dynamics, environmental sustainability, and social inclusiveness. These happen alongside continued low-road, low-cost-and-price strategies. Findings highlight China's Schumpeterian-typed government-led entrepreneurship in successfully combining R&D- and other-knowledge-based policies with other conventional industrial policies and elements, for global-frontier industrial and green transformations and competitively inclusive sectoral development. Differently, Thailand's inadequacy of domestic- but TNC-led entrepreneurship for commanding R&D-based high-road strategies has kept the country sluggishly upgrading along the low-road pathway, with partial transformation towards only poverty reduction.

Keywords: Asian, China, high-road industrial strategy, industrial policy, middle-income country, Thailand
JEL Classifications: L52, O25, O38, O53

Introduction

Incorporated by some official documents (e.g. European Commission, 2010, 2012; OECD, 2012; UNCTAD, 2016) and academic studies (e.g. Aghion et al., 2011; Stiglitz, et al., 2013; Rodrik, 2014; Bailey et al., 2015A, 2015B, the modern, 'high-road' industrial policy is crystalized into a set of strategies for generating structural transformation and wellbeing with innovation-driven economic dynamics, environmental sustainability and social inclusiveness (Stiglitz et al., 2013; Aiginger, 2014; Bailey et al., 2015A). In these documents, the policy is projected for developed, high-income countries' fortune against the old, 'low-road' industrial policy based on low cost and price competition consigned for developing, low- and middle-income countries' sole economic growth. Differently, this paper presents a conceptualisation and evidences of high-road industrial policy contemporaneously adopted by two different Asian middle-income countries. The paper is to accentuate such complex competition and to argue for expanded opportunities for developing countries in augmenting competitiveness with the high-road industrial policy alongside other low-road strategies they may implement. Advanced countries may also recognise such complex and intensified competition. Essentially, the high-road mixes are well matched by the United Nations' 2030 Agenda for Sustainable Development which encompasses 17 goals for reinforcing growth, inclusive and sustainable development (UN, 2015). The reinforcing elements may then be lumped together as "outcome competitiveness" (Aiginger, 2014; Bailey et al., 2015A).

The study on above hybrid industrial strategies is rare, and this paper is to contribute to the line of literature. In doing so, the paper studies comparative cases of China and Thailand, middle-income countries which emerge with clear evidences of above hybrid industrial policy. As discussed in the following section, the evidences contest the stage theory, chiefly Kuznet (1955)'s hypothesis which has recently been extended in arguing that both economic inequality and environment degradation have a rigid relationship with per capita income (rising with and then declining at certain point of higher income level along the inverted-U Curve (Kuznet, 1955; Dinda, 2004). Alternatively, we generalise Schumpeter (1934)'s concept of entrepreneurship-driven economic development to explain broader economic, environmental and social sectoral transformations. The concept can be applied to either the case of low-road or high-road pathway, or the mix of the two concurrently. In the subsequent section, the concept is initially applied to explain the low-road pathways of China and Thailand before 2000, emphasising that the low-road transformations were driven by typical entrepreneurships, not high-road visions, initiatives and regulatory mechanisms that already been adopted by the two countries. In the sections that follow, the concept is applied to a comparative analysis of high-road industrial policies, combined elements and policies, and competitiveness outcomes--comprising innovation-driven economic dynamics, environmental sustainability and social inclusiveness--of China and Thailand. The final section concludes and points to both theoretical and policy implications.

Contesting evidence, contesting literature

The latest World Economic Forum (WEF)'s 2018 Inclusive Development Index (IDI) reveals higher aggregate scores (in a 1 to 7 scale) for China and Thailand than for some high-income countries, with China's and Thailand's five-year IDI trends ranked fifth and ninth of the world, respectively (WEF, 2018). With the aggregate IDI calculated from a composite of inclusive and sustainable elements, including levels of GDP per capita, employment, poverty, inequality, ecological-adjusted net savings and carbon intensities, this generally signifies that the two now middle-income, not high-income, countries may now be among leaders of global high-road inclusive and sustainable development. Before we scrutinise into stylised facts of the high-road pathways of the two countries below, we initially note that: the above information contests the mentioned Kuznet (1955)'s hypothesis and point to the need for an alternative concept to explain such rises of the two countries in high-road development whereas they are now also depending on their low-cost competitions (McKinsey Global Institute, 2015; Asian Development Bank, 2015). There emerges a parallel study on firms in transition to the frontier concurrently adopting a mixture of leadership, followership and latecomer strategies (Hobday et al., 2004). At the systems level, few studies reveal frontier socio-environmental sustainability niches already emerging and interacting with socio-technical regimes in developing countries (e.g. Berkhout et al., 2009, 2010). However, the first focuses on the firm level while the second explains small niches. We then propose a broader, applicable to the country level, Schumpeterian concept of entrepreneurship-driven socio-eco-economic development as the framework for the study. The Schumpeterian concept is also expected to be able to explain more purposive, policy orientations of economic, environmental and social sectoral transformations.

An extended Schumpeterian concept of entrepreneurship-driven "new combinations" and sectoral socio-eco-economic transformations

Schumpeter's theory explains a structural change occurred by the creation of new sectors and adding them to the old sectors. The creation of a new sector is done by the group (s) of leaders (or entrepreneurs in a capitalism system), the superior ones succeeded by the following ones, who make "new combinations" out of old (Schumpeter, 1934) or new (Schumpeter, 1942) technical knowledge and other combined elements. In economic area, the new combinations are new products, new production processes, and related new organisations and industries, part or all also called innovations. Economic development is simply the above process, in which the heart of the transformation is the leaders (entrepreneurs) who do the new combinations or do "entrepreneurial function" or have "entrepreneurship'. Note that any agents, individuals, firms or governments, doing other functions or jobs can at the same time do the entrepreneurial function (Schumpeter, 1934, p.78). Extended to social and environmental areas, the new combinations are simply new social and environmental artefacts and related sectors. Additionally, the above entrepreneurial function implements the transformations of technical knowledge and other combined elements as artefacts (in a capitalist market the implementation is commercialisation). Therefore, without entrepreneurship there is no process that the new technical knowledge and its combined elements (on the supply side) will automatically create new artefacts and related sectoral transformations (on the demand side). In the experimentation process with uncertainty inherent in each separated or aggregated socio-eco-economic transformations, entrepreneurs adaptively, with successes and failures, carry out the entrepreneurial function in anticipating for their adaptive "expected surplus value" derived after subtracting all economic, social and ecological costs (all knowledge and resource utilisation, price change and transaction costs, and the like) from all typical returns. In this framework, new combinations (innovations) are only the successful cases (after trials and errors), under which the entrepreneurs gain their entrepreneurships.

Because of newness of the new combinations, their acceptances, adoptions and diffusions over the economy face varieties of uncertainty, not only those related to market prices and costs but also delays, hurdles and institutional resistances (Schumpeter, 1934, p.79, 85). Therefore, in addition to "foresight", visioning the expected surplus value possible derived from the commercialisation of technical knowledge, and "initiatives", leading the carrying out of varied entrepreneurial functions, the entrepreneurs are characterised with "authorities" to interact with and conquer (in some cases, simply persuade to resolve) such impediments and uncertainties for the successful implementation of the new combinations (which add new sectors to the existing ones). By their authorities, they are able to command, in one or the other way, indispensable innovation financing and, in our extension below, arrays of technological knowledge, industrial and other related policies and other resources, all that required for new combinations. In a free market system, private entrepreneurship may command all these elements better than government entrepreneurship, or vice versa.

Borrowing an additional concept from Utterback and Abernathy (1975), we simply group technological knowledge into two groups: fluid and mature (solid) technological knowledge. The former is usually at the technology frontier or associated with emerging technologies and needs research and development (R&D) for its generation and/or assimilation (Cohen and Levinthal, 1989). The latter is usually behind the technology frontier and may require R&D but more of other formal and informal forms of technological capabilities for absorption and assimilation. Mainly for innovation-driven economic transformation and partially for social and environmental transformations, the frontier, fluid technological knowledge is more associated with the high-road mixes, the mature, solid technological knowledge is more connected to the low-road ones. As entrepreneurship is defined above, the entrepreneurs can select and command any or both types of technological knowledge for their adaptive portfolios of socio-eco-economic new combinations. But, R&D is needed when utilising the fluid one.

Finally, we extend Schumpeter's concept of innovation diffusion process in the market economy which points to cluster- or swamp-like diffusions of successive new combinations into the economy. Given unequal qualities of the entrepreneurs (Schumpeter, 1934, pp. 81-82), the best groups lead the making of the new combinations, followed by successive groups of entrepreneurs with lower qualities but learning from the forerunners and feedbacks, until all the new technical knowledge is commonly known, the new combinations are the commons, and the latter are fully added as regular sectoral components (in our case below, of all socio-eco-economic structure). The above diffusion process also allows either leading government entrepreneurs or private ones or both of them to lead any following groups of entrepreneurs. In sum, the Schumpeterian framework is opened for studying any adaptive, specific cases of socio-eco-economic new combinations (and derived sectoral transformations) that are driven by entrepreneurships, one after another, aiming for adaptive expected surplus values from the implementations (commercialisations) of technical knowledge and other matched policies and components as the new combinations.

Adopted high-road foresights overshadowed by low-road industrial transformations in China and Thailand

In this section, we accentuate that simply-adopted industrial policy foresights (visions), as revealed by sheer plans and regulations, or even policy initiatives (which are necessary) may not sufficiently bring in full industrial transformation, unless full entrepreneurship is filled also with "authority" to

China	Thailand
Adopted visions and initiatives on R&D and S&T utilisation	
-Decision on the Reforms of the S&T System (1985 designating for the utilisation of R&D in production from 1985 to 1994, oversaw by Ministry of Science and Technology and National Development and Reform Commission -Strategy of Revitalizing the Nation through Science and Education (1995 to mobilise more agencies to participate in R&D -State Council's Opinions on Accelerating the Development of Private Technology Enterprises (1999) for private R&D utilising	- The 5th Five-year National Social and Economic Development Plan (1982-1986) strategizing the use of imported technology and own developed technology -National Biotechnology Research Centre (1983). -National Electronics and Computer Technology Research Centre and National Material Technology Research Centre (1986) -S&T Development Bill and S&T Development Committee (1991) -R&D incentives: 150 percent tax reduction for R&D activities (1994, revised to 200 percent in 1996)
Adopted visions and initiatives on socio-economic inclusiveness	
-China Poverty Alleviation Program (1986 for reducing poverty and bringing economic growth to under-developed regions - Spark Program (1986) for utilising S&T for development of agriculture, rural areas, healthcare and entrepreneurship -Western Development Strategy (1998) for development of regional areas	- Investment Promotion Law revised (1977) to promote regional industries -The 5th Five-year National Social and Economic Development Plan (1982-1986) strategizing systematic poverty reduction and area-based inclusive work and income distribution -The 8th Five-year National Social and Economic Development Plan (1997-2001) strategizing human-centred and good governance developments
Adopted visions and initiatives on ecological sustainability	
-Agenda 21 for sustainability (1994 -Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste (1995). -Law of the People's Republic of China on the Desert Prevention and Transformation (2001) -Cleaner Production Promotion Law (2002, revised in 2012)	-Environmental Protection and Conservation of National Environmental Quality Act (1975, revised in 1992). -The 7th National Social and Economic Development Plan (1992-1997) strategizing sustainable development. -Renewable Energy and Energy Conservation Promotion Act (1992, revised in 2007 -Agenda 21 for sustainability (1993) -National Plan for Enhancement and Conservation of National Environmental Quality (1997)

Table 1. *China's and Thailand's adopted high-road visions and initiatives*
Source: Respective authorities' documents

make policy implementation. Full entrepreneurship is required for implementing knowledge, plans or regulations as artefacts. This is evident by both cases of China and Thailand that adopted their high-road foresights and initiatives on R&D-driven, inclusive and sustainable developments from the 1970s to the 1990s, but have not fully implemented them. Table 1 illustrates that China had consecutively issued high-road plans and strategies to utilise R&D and science and technology (S&T) for production among private enterprises since 1985. For inclusiveness, it had adopted programmes for poverty reduction and developments of needy sectors and regions since 1986. The country had also adopted Agenda 21 for sustainability since 1994 and continually issued laws for environmental protection and clean productions. Similarly, Thailand had incessantly set plans, frontier research centres and incentives for augmenting R&D since 1983. For inclusiveness, it had since 1977 issued laws and plans to promote regional industries, systematic poverty reduction, area-based inclusive work, income distribution and human-centred and good governance developments. Finally, the country had since 1975 issued laws and plans for environmental protection, sustainable development, renewable energy and energy conservation and adopted Agenda 21 for sustainability. Even with the plans and strategies, the entrepreneurships in the two countries mainly pushed, with other low-road policies and suitably combined elements, for their industrial transformations based mainly on low-cost competitiveness, as explicated below.

The low-road industrial transformations in China and Thailand

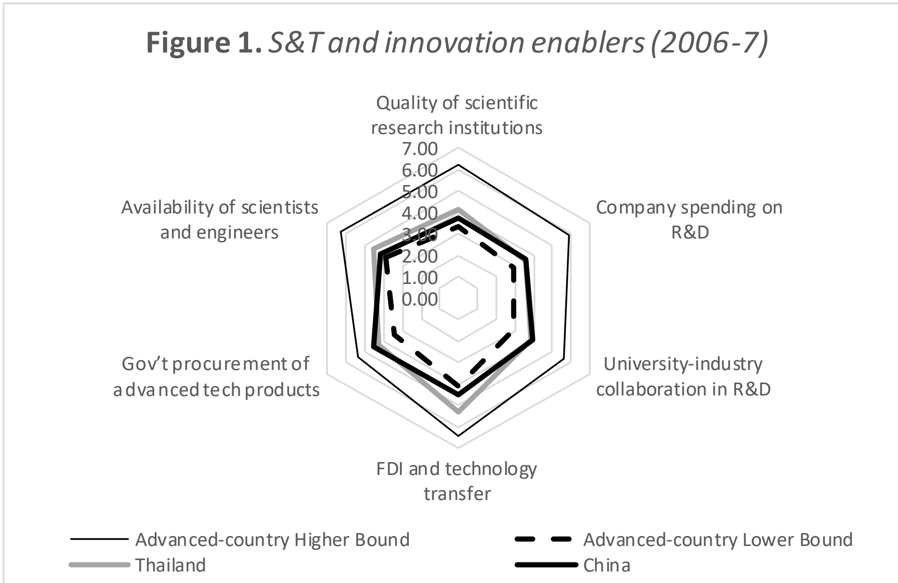
From the 1970s to 1990s, the two countries relied mainly on mostly imported mature technologies, with relatively less fluidity and more incremental improvement, and endowed low-wage labour and low-cost natural resources, to carry out Schumpeterian innovations in new labour-intensive manufacturing products, processes, (though old in other places), related organisations, and industrial segments, first adding to the agricultural sector. Later, the new labour-intensive manufacturing segments were added by subsequent capital-intensive industries (Lo and Wu, 2015; Asian Development Bank, 2015), in a catching-up mode. Their new products and industries competed in world markets during the time under their increasing trade and investment liberalisations, with degrees of technological and production capabilities upgrading and learning (Brimble, 2003; Yao, 2003)

Diversely, however, those of China was characterised by government-led industrial leadership while those of Thailand was a private-, chiefly transnational corporation (TNC)-, led type. The Chinese government led undertaking entrepreneurial function creating new industries through: entering new industries by its state-owned enterprises (SOEs), SOE bank's financing, creating and supporting matched human and organisational technological capabilities, bridging and networking value-chain counterparts in special estate zones (SEZs) and industrial clusters, procuring new industrial products, and other price and cost subsidies (Gabriele, 2010; Poon, 2014; Lo and Wu, 2015). All of these are typical conventional industrial policies. Domestic and foreign private entrepreneurs followed. The diffusion of entrepreneurships helped to create and upgrade industries, of which textile, commodity chemicals, electrical equipment, consumer electronics, construction machinery and materials and steel have recently continued competitive (McKinsey Global Institute, 2015).

In Thailand, TNC entrepreneurs, followed by Thai private firms, had led industrial transformations under fragmented price/ fiscal- based protections before gigantic trade and investment liberalisations in the 1980s. If the government had some entrepreneurship, it was when it accorded Thai business associations in general trade negotiations and investment promotions. From the late 1980s, it improved its roles as key market enabler and facilitator, infrastructure provider, and regulatory maker that increasingly fitted the World Bank (1993)'s 'East Asian Miracle' than most of other countries. Its core policy instruments became associated with neo-liberal ideas and market-friendly and market-failure interventions (Intarakumnerd and Chaminade, 2007). TNC, chiefly Japanese, entrepreneurs led certain large domestic firms upgrading industries, of which manufactured foods, petro- chemicals, electrical and electronics equipment and automobile industries have recently remained competitive (Asian Development Bank, 2015; ESCAP, 2017). All these have been done in a catching-up mode within a range of mature technological regimes.

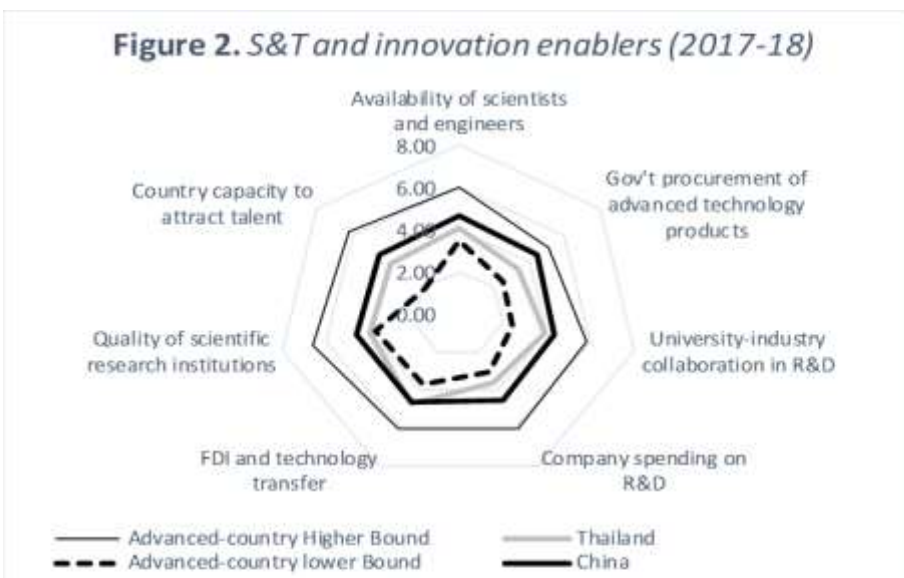
Comparable grounds on S&T and innovation enablers

Both China and Thailand have evidently initiated the high-road strategies on top of their continued low-road strategies, in expecting for enlarged competitiveness and socio-eco-economic values from both high- and low-road strategies. Initially, both countries, through different institutions, have since the early 2000s uplifted S&T infrastructures and innovation enabling factors (which already had solid roots before the 2000s). Just as above technological capabilities utilised during the low-road transformations, these elements have been scaled up, given their known qualities as necessary complimentary factors to the innovative- and R&D-driven transformations (Lo and Wu, 2015; CAS, 2016; Intarakumnerd and Chaminade, 2007). Figures 1 and 2 compare selected S&T infrastructures and innovation enablers of China and Thailand with those of 30 advanced countries, based on WEF's 2006-2007 and 2017-2018 Global Competitiveness Index databases. The selected elements embrace: availability of scientists and engineers, quality of scientific research institutions, company spending on R&D, university-industry collaboration in R&D, government procurement of advanced technology products, FDI and technology transfer, and country capacity to attract talent (the latter not available in the 2006-2007 database). The competitiveness scores (all scaled from 1 to 7) for each country are based on the latest meta data available (on the year or one to two years before). Interestingly, the 2006-2007 indices in Figure 1 signifies that China and Thailand, given their investments and build-ups in these elements, were already better than some advanced countries closed to the advanced countries' lower bound. Thailand performed slightly better than China in FDI and technology transfer, availability of scientists and engineers and quality of scientific research institutions categories. Note that at the time China and Thailand remained classified as lower-income and lower-middle income countries, respectively.



Source: World Economic Forum's 2006-2007 Global Competitiveness Index database.

The 2017-2018 indices in Figure 2 indicates that Thailand remains better than some countries closed to the lower bound of the advanced countries. However, China progresses further approaching the middle range between the upper and lower bounds of advanced countries, with the government procurement of advanced technology products the best performing indicator.



Source: World Economic Forum's 2017-2018 Global Competitiveness Index database.

Different perspectives of the high-road transformations in China and Thailand

Differently, the government-led entrepreneurship in China has continued leading the country to successfully combine R&D- and other-knowledge-based policies with other conventional industrial policies and above S&T and innovation enabling elements, for global-frontier industrial and green transformations and competitively inclusive sectoral development. Meanwhile, Thailand's inadequacy of dominant domestic- but TNC-led entrepreneurships for commercialising R&D bases in frontier industrial transformations has kept the country sluggishly upgrading the still-competitive industries created during the low-road transformations. The inadequacy of government and/or domestic private entrepreneurships has also left regulatory and incentive instruments apart from the implementation of sustainable and inclusive sectoral transformations. Yet, Thailand's National Science and Technology Development Agency (NSTDA)'s S&T utilisation support programmes have helped to sustain productivity and income of some SMEs and community enterprises, which have not received typical supports from domestic and global production networks and value chains (UNCTAD, 2015; ITAP, 2017). What the two countries share remains low poverty incidence and high inequality.

Government-led entrepreneurship and the full implementation of S&T-based high-road initiatives in China

Resilient government-led entrepreneurship and R&D-driven high-road industrial policy

Challenging stage-development and trickle-down theories (i.e. Kuznets, 1955; Aghion and Bolton, 1997), leaders in China's central government have since the early 2000s led R&D-based new combinations in many targeted industries. Their core policy frameworks, interactively launched and shaped by leading groups from China Academic of Science (CAS), Ministry of Science and Technology (MOST) and related organisations under the State Council and core government ministries (Ahrens, 2013), include the Medium and Long Term S&T Development Plan 2006-2020 (MLP), series of subsequent Five-Year National Plans, and bunches of related sectoral plans continually issued up to the present. All have made a solid focus on incessantly developing "indigenous innovation-driven transformation" in economic growth, social inclusion and ecological sustainability (European Commission, 2015; CAS, 2016). The government entrepreneurs have exerted their authority pushing not only for technology absorption and assimilation but also generation, and not only for resultant higher expected economic surplus values from innovation at industrial frontiers but also higher expected socio-eco surplus values from increased social inclusiveness and ecological sustainability. These high-road competitiveness outcomesand their related supporting elements, though having earlier roots, have been intensively debated and aspired for in China since the early 2000s (Lo and Wu, 2015, CAS, 2016). From the MLP to the latest "Made in China" and "Internet Plus" policies, all the related policies and plans have always targeted specific technologies and industries; some are drawn-out and others are added.

Although China then succeeded in some technology upgrading under joint-ventures between SOEs and TNCs, i.e. in automotive and semiconductor sectors, TNCs generally hesitated to transfer frontier but mature parts of technologies. This was coupled by low technology spill-overs to domestic firms from rising R&D centres of TNCs and high balance of payment deficits for royalty and license fees and trade deficits in some sectors, such as integrated circuits (Poon, 2014; Lo and Wu, 2015). The government then strongly attempted to reduce the technology dependency. With their leading entrepreneurship, the government leaders utilised R&D bases for seizing frontier technologies in both existing and emerging industries, which would generate higher expected surplus values. The R&D bases were also crucial for inclusive and sustainable transformations, which required new technologies to improve public health and wellbeing and sustainable uses of resources and energy, and to reduce poverty and ecological problems (Schwaag-Serger, 2007; CAS, 2016). Given limited international transfers of these technologies that were affordable and locally suitable to mass applications and diffusions in China, indigenous R&Ds were indispensable.

Of course, the central government's continued push for indigenous R&Ds has faced obstacles, successes and failures. Initially, critiques arose about the potentials that the government would successfully lead the private firms, particularly SMEs, to carry out and diffuse the planned R&D-based indigenous innovation. SOEs which then undertook R&Ds more than private firms were critiqued with lower innovative and absorptive capacities than the latter. Most Chinese SMEs did not even demand high technologies (Schwaag-Serger 2007). As the policy has progressed, China's R&Ds and their related S&T and innovation enablers has been gauged with abrupt rises in quantity but not much in quality (European Commission, 2015). The R&D-based transformations have remained conjugating in only old high-technology SEZs and cities along the East Coast (Rodríguez-Pose and Wilkie (2016). However, as explicated, the government-led entrepreneurship has finally driven China's competiveness in S&T and innovation enablers to the mid-range of advanced countries, given they are also required for the new combinations of R&D-based transformations. With following groups of large and SME entrepreneurs, many of China's industries have become global-frontier and green-growth leaders by the R&D-based industrial policy. Coupled with other traditional industrial policies and existing S&T bases, the policy has also led to degrees of inclusive and sustainable transformations.

China's different perspectives of high-road industrial transformations on top of competitive low-cost industries

As mentioned, China's successive R&D-based industrial transformations carried out by both government and following private entrepreneurships have been on top of the country's existing low-road industrial developments. China has still competed effectively in some low- and medium-technology segments of industries, including textile, commodity chemicals, electrical equipment, consumer electronics, construction machinery and materials and steel (McKinsey Global Institute, 2015). Adding new R&D-driven industries helps to realise higher expected surplus value and makes the country's structural change more sustainable. Yet, the R&D-based, mostly high-technology, industries China has just created and/or extended within the past decade contain unique high-road industrial mixes, truly valuable for investigation and learning from.

Part of the high-road mixes that have uplifted China to the global frontiers include high-speed railway and commercial aircraft. R&D utilisations in these industries have mainly functioned as capacities to absorb and assimilate existing knowledge for innovation rather than creating new-to-the-world knowledge. New combinations of R&D and other industrial policies have been done to leapfrog China to each industry frontier. Specifically, in the high-speed railway industry the Chinese government utilised two SOE operators, invested in huge railway infrastructure, financed them by SOE banks, and procured trains and related equipment and production facilities by allowing competition between different foreign market leaders to secure contracts and optimised broader technological transfers to the SOE operators. The SOEs employed R&D to digest the original imported technologies and augment a level of design of new trains (Fabre and Grumbach, 2012; Lo and Wu, 2015). This typical combination of industrial policies has also been used in the commercial aviation industry which has also been led by SOEs but with more R&D components at the start (Fabre and Grumbach, 2012). Facing uncertainty and the challenge of train cash in 2011, the railway operators have utilised R&D to support their positions as the global leader (with global market share more than 40 percent) and in exporting trains, systems and know-how to different countries (McKinsey Global Institute, 2015). In the latter industry, SOEs initially failed to increase their global market share after leapfrogging but have gradually raised it.

An alternative model has ensued in the transformations of solar photovoltaic (PV) and wind power industries where many small- and medium-sized enterprises (SMEs), large enterprises, local governments and the central government interacted to create frontier technologies and industries in a broader innovation ecosystem. The private enterprises began the assimilation and upgrade of required technologies for creating the industry in China before the 2000s through licensing, joint ventures, acquiring global firms, and recruiting scientists trained at global labs (Hopkins and Li, 2015). With the central government's renewable energy programmes that subsidised indigenously produced contents and R&D-based policies that provided funding, fiscal incentives and/or SOE bank's financing for R&Ds, the private firms have been pushed to augment the industries' competitiveness to become the global leader. Consequently, Chinese firms have filed enlarged patent registrations (Li and Fan, 2018). Other coupled industrial policies included price supports in the form of feed-in tariffs. Local governments, which oversaw high-technology SEZs to support technology upgrading for SMEs but tended to support low-cost growth strategies, were also interactively forced to support the above R&D-based policies. The above supports were removed from the private firms unless they met the indigenous content and R&D requirements (Nahm, 2017). More SMEs entered the industries when local governments adapted to subsidise production costs with lower prices of rent in their SEZs and loan guarantees on condition that the firms met short-term production targets and revenue requirements; favoured tax status to mini and micro businesses were also strictly imposed (Li and Fan, 2018). Therefore, the industries have faced interactive local experimentation of industrial policies. The central government has issued measures to establish standards for quality improvement while the enterprises have also governed by international standards of the competitors. Local governments have also required them to meet cost and production targets for better and faster manufacturability (Ibid.). Adaptively, the enterprises have divided R&D activities into one part that has targeted on developing new technologies and the other, the majority, that has focused on assimilating new technologies through global value chains for scaling-up mass production (Nahm, 2017). With varied technique-related competitions and market slumps, their entrepreneurships have been tested through uncertainties (Hopkins and li, 2015) and anti-dumping actions against their alleged price dumping.

Essentially, all dimensions of China's R&D-based industrial policy may be reflected by industrial transformations in information and communication technology (ICT) industrial clusters. Leapfrogging in the telecommunication industry, the Chinese government exerted its entrepreneurship to command the creation, standardisation and diffusion of the new 3G, TD-SCDMA mobile phone system at the time domestic mobile switch and handset vendors remained reluctant to switch from the licensed US systems (Gao, 2015). The government used its budget to fund China Academy of Telecommunications Technology (CATT), a government research institute (RI), to partner with foreign license holders and a high-technology US firm to make huge R&Ds to develop the required technologies (Ibid). Ministry of Information Industry (MII) transformed CATT into a holding company Datang Group, provided its son company Datang Telecom with R&D funding, and in testing and standardising stages had it to work with an industry consortium embracing foreign and domestic firms, such as Huawei, ZTE and Putien. The formed R&D and industrialization programmes were then to subsidise the domestic firms. Many patents were created by the parting firms (Lui, 2007). MII also requested SOE banks to extended preferential loans to the domestic counterparts. In 2009, MII issued 3G operation licenses and granted China Mobile (also SOE) to operate the system (Gao, 2015) which monopolises over China's gigantic market. The above industrial transformation also built up the high-road pathways of Chinese private firms, some of which had before done some R&Ds as absorptive capacities, but now in performing R&Ds that connected to frontier technologies. In 2017, Huawei and ZTE rose to world top-two international patent filers. China's increased patenting in the telecommunication sector also drove the country to be world second (after the US) in patent filing (WIPO, 2018). With extended R&D base, Huawei has itself entered and become the world's strongest player in 4G and telecom systems and equipment (WEF, 2016)

Overall, the conduct of the above industrial policy denotes the government entrepreneurship as follows: fiscal funding RIs and universities to absorb and create specific frontier technologies; transforming the RIs into holding companies and funding their invested and son firms with budgets for R&Ds and development programmes joint-carried out with particular universities, foreign and Chinese private firms, of which the latter are to learn, extend upon the technologies and become role model 'national champion'; utilising firms in the holding groups and the Chinese firms in final commercialisation; and creating own technology standards and specific subsidies to protect and sustain Chinese firms in the markets. By the policy thrusts, participating Chinese companies have been enforced to extended their high-road entrepreneurship, commanding R&D inputs and outputs (patents) as their strategic features to augment competitiveness. Such model has also been employed in the high-performance computing (HPC) industry which drove China's HPC to be the global leader in 2017 based on overall speed and processing capacity (USSC, 2017). In this case, CAS is the core of RIs, here co-working tighter with universities in technology development, and Lenovo, a companied invested and controlled by CAS's Legend Holdings, and some other Chinese firms (including Inspur and Sugon) are the supported companies that assist carrying out commercialisation. These Chinese companies now are among HPC top 500. The HPC transformation was supported by the government's intervention to have HPCs' integrated circuits (IC) designed and manufactured in China. China has turned to the HPC and IC industries with the expectation that they will support security-related industries and most dynamic digital transformations: artificial intelligence (AI), internet of things (IoT), etc. (Ibid.). In the IC industry, the government has added to all above tools a new market-based instrument, the National IC Fund, which has supported joint ventures between SOEs, research institutes and domestic firms, of which the leading ones include SMIC and DOE. The fund has invested on fab and IC design companies, and has stimulated IC industry M&A activities in and outside China (Chu, 2017).

Lastly, the most dynamic module of China's high-road industrial policy may be exemplified by the developments in emerging technologies and related industries. Through unrelenting developments, China's R&D enablers and activities and technology commercialising capabilities are now pervasive among all domestic parties—central and local government agencies, RIs, universities, large firms and SMEs, any of which could be leading entrepreneurs. Given this, the government add to above industrial policy components more market-friendly instruments to support the swamps of entrepreneurs, especially in the area of technology commercialisation. Recently, the government, local governments and state-owned companies set up government guidance funds (GGFs) to invest in strategic domestic start-ups and venture capitals amid corresponding investments by large high-technology firms, especially in biotechnology and related healthcare and AI. In AI-related industries, together with the central and local governments' elevations of previous talent programmes such as 'Thousand Talents' plans that use rewards to attract foreign AI talents to China, large Chinese technology companies such as Baidu, Alibaba and Tencent have established overseas AI institutes to recruit foreign talents (Ding, 2018). These upgraded ecosystems are on top of rising R&D bases of China which broadly catch up with the US and outplace it in AI-related patent registration and articles on deep learning (He, 2017). They are also buttressed by the government's upholding of the HPC industry and indigenous IC transformative projects. Some outcomes include the development of chips that are six times faster than the standard GPUs for deep learning applications by Cambricon, a state-backed start-up. Huawei have recently boasted surpassing Apple in mobile AI chips (Ding, 2018). It is expected that this module is also used in China's competition in other targeted emerging technologies, such as robotics, quantum information science, nanotechnology, and biotechnology (USCC, 2017)

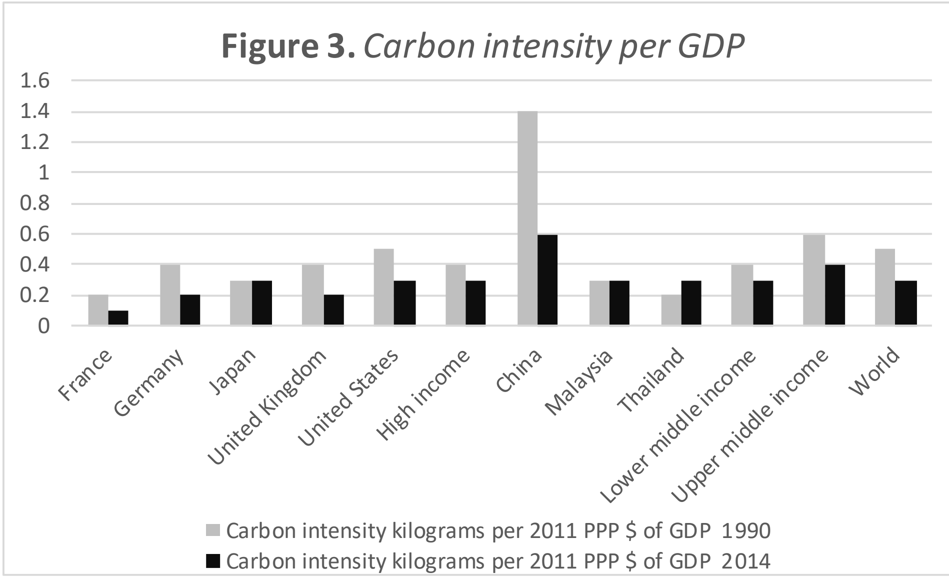
Growth, sustainability and inclusiveness elevated by China's unique R&D-based green industrial transformations

Another unique characteristic of China's R&D-based high-road industrial policy is that the competitiveness outcomes of the policy along the three lines of development--the innovation-driven economic dynamics, socio-economic inclusion and ecological sustainability--have come in bundles and strongly overlapped by the multi-facet of China's R&D-based green industrial transformations. With some other industries below, the frontier high-speed railway and PV and wind power industries have provided simultaneously (but to differently degree) economic growth, environmental sustainability, and employment and inclusiveness. China's overall green transformation has then been raised by creating the green industries on top of the country's gradual strengthening of environmental regulations and energy-efficiency market-driven mechanisms.

That is, along the pathway shaped by the MLP and related following plans, from the mid-2000s the Chinese central government has also intensified the utilisation of incentives and regulations to push private firms and local governments for better environmental protection and energy efficiency. In this respect, different responses to the regulations have been monitored for adjustments. China's eastern provinces have gradually from the late 2000s improved by market-driven resource usage efficiency and pollution controls to meet more sophisticated foreign investment demand (Berkhout et al., 2009). However, with specific policies to develop the western and central regions, newly-bulit infrastructures and equipments, and creations and transfers of technology-intensive production (as above green industries), the western region have from 2004 to 2012 registered higher green productivity growth than the eastern region (Li and Lin, 2016). Lately, OECD's Environmental Policy Stringency (EPS) data has revealed that the stringency of environmental policies in China has amplified over the past 15 years, approaching OECD standard. The use of environmentally related taxes in China has at the same time expanded, with the share in total tax revenues in 2014 about 1.3 percent of GDP, almost reaching OECD average. Like in OECD countries, the taxes have mainly targeted on transport and energy, with attempts have also been to phase out inefficient fossil fuel subsidies and to move towards more market-based pricing of energy and resources (OECD, 2017A). Additionally, China already spends annually approximately 1.2 percent of GDP on environmental protection, mostly on industrial pollution. This is higher than an average spending between 0.5 to 1 percent of GDP performed by high-income European countries (World Bank, 2017).

Given the considerable progresses in the regulation of environmental protection and resource and energy usage efficiency, the rises of above frontier green industries put on top of them more sustainability to China. Apart from these, China's hydropower industry is another global leader (UNIDO, 2016). China's SOEs have led the industry based on R&D and technology transfers to Europe and Latin America (Kirchherra and Matthews, 2018). As in PV and wind power industries, SOEs, large firms and many of SMEs in the industry have also received typical specific-programme, price/cost (feed-in tariff), financing, R&D funding, fiscal and procurement supports from both the central and local governments (Li and Fan, 2018). China already became the world leader in renewable energy, with its share of renewable energy supply in total primary energy supply about 11 percent higher than the OECD average of 9 percent in 2014 (Ibid.). Lately, OECD (2017A) identifies new renewable energy industries as a key success of China's greening growth. Furthermore, the country also made about 32 percent global clean technology sales, which comprise energy efficiency products, solar PV panels, wind turbines and batteries, by the supports of stable government policies, strong applied R&D and well-developed supply chain (van der Slot and van den Berg, 2012). Yet, more R&D supports have recently been witnessed in the development of electronic vehicles (EV) in China where now SOEs have led the market of SME part producers, given previous failures to indigenously seize frontier technologies under the joint ventures with foreign automakers. Since 2016, Chinese EVs have already made the world's largest electric vehicle market, and the growth of the industry is expected providing the procurement of certain EVs by local cities (Bay Area Council Economic Institute, 2017).

With the government-led entrepreneurship, China has currently experimenting with less direct supports and more market-driven mechanisms. The developments of the green industries have supported China to dominate the Clean Development Mechanism (CDM) market with 3,935 CDM projects, about half of world CDM projects in 2012 (Kinkead, 2012). All transformed China's innovation system into global green system of innovation (GGSI), which reinforced global creation and diffusion of knowledge conducive to the reduction in greenhouse gas (GHG), biodiversity conservation and natural resource preservation (Marinova et al., 2013). Since 2017, power-quota assessment and qualification procedures, green power certificates and a nation-wide carbon emissions trading scheme have been enforced in China (OECD, 2017A; Li and fan, 2018). The Chinese government has also extended its leadership in the G20 context to promote green finance while the People's Bank of China, alongside other institutions, has led delivering guidelines for instituting a green financial system (OECD, 2017A). The approach is viewed more apposite than subsidizing pollution control. Overall, the above green transformation mixes have made stronger progresses. SO_2 and NO_X were even decoupled from China at an earlier stage of economic development than in OECD countries at comparable stages of development. Technological leapfrogging and policy convergence directed at improving environmental situations have led to this achievement (Ibid.) Although current CO_2 emission in China is higher than in any country, the high-road policy mixes have already reversed China's course of low-cost environmentally-deteriorating development pursued since the 1980s. Figure 3 shows that China is the world best performer in reducing half of its carbon intensity per GDP from 1990 to 2014.



Source: World Bank

Furthermore, with the central government's increased supports of smart grid technologies and infrastructures and full purchase, and local governments' adding matched supports, China's renewable energy production and utilisation have penetratingly spread across regions, including the Northeast, Northwest, and North where related resources are plentiful. Direct current transmission networks have also been extended to support western regions to sell electricity to eastern regions (Li and Fan, 2018). This has effectively brought in not only innovation-driven and sustainable industrial transformations but also inclusive development across regions and rural areas, given stretched business activities, employment and income distribution. Some renewable energy programmes were evidently poverty alleviating programmes (Ibid). While wind and solar PV farms have increasingly diffused farther across provinces outside high-technology SEZs, small hydropower projects have proliferated in rural areas where water resource is abundant. Given socio-economic negative side-effects of large and some small hydropower projects in some areas, much of R&D supports have also been targeted to reduce such side effects. In 2011, the small hydropower segment already shared more than 23 percent of China's total installed hydropower capacity (UNIDO, 2016). Therefore, it has progressively provided China's high-road socio-eco-economic mixes. This is evident that, apart from rising income generation and related employment, the sector provides natural and energy conservation and greenhouse emission reduction, improves farmers' production and living conditions, and promotes rural economy and society development (Kong et al., 2015; UNIDO, 2016).

Broader S&T-based inclusive transformations in China

With above stylised facts, we may say that China's above high-road industrial policy has propelled the country to the global frontier of high-road competitiveness, at least regarding its positions at many global industrial and greening frontiers. Respecting inclusiveness, the above developments may also support degrees of income and green growth distributions that improve wellbeing of households and SMEs in regional and rural areas. Boosting economic growth, they may also partly actualise the country's poverty reduction, under which the poverty headcount ratio (at $1.90 a day) has consistently fell from 40.5 percent in 1999 to 3.1 percent in 2017, assumed that growth drives down poverty (World Bank, 2017). Therefore, poverty reduction has been successful, and there exists a bottom line of social assistance scheme, a minimum living standard programme (dibao). The targeting and coverage of social assistance have better recently, even though there remain significant disparities in benefits at the local levels. (OECD, 2017B).

China's inequality measured by the Gini coefficient of 0.46 in 2016 was still high compared with most of OECD countries. Yet, it has been declining after peaking at 0.49 in 2008. The inequality has been improved by different measures under the MLP and related following plans although conventional taxes and transfers have little redistributive impact (Ibid.). Many other government policies outside the tax-and-transfer system can narrow inequities within the population, including those pertaining to public education, healthcare and the pension system (Solt, 2016). The most favourable trend is the regional income convergence, with the central, western and northeastern regions of China making progress catching up with the east, and urban-rural income gap becoming narrow. The share of the rural population living below the poverty line also fell from 30% in 2005 to 5.7% in 2015 (OECD, 2017B; World Bank, 2017). Respecting only inclusiveness, China's low-cost industrial transformations along stretched out cities, SEZs and rural areas have partly been sources of the income convergence, as the China Western Development policy (CAS, 2016).

In the complex transformations above, Schumpeterian innovation-driven industrial development usually lead the entrepreneurs to gain the expected surplus value (accrued as wealth), leaving other competitors (especially those in traditional firms) behind. Hence, bridging the gap implies a diffusion of entrepreneurships in the new frontier industries to the broadest groups of following entrepreneurs as rapid as possible; or, industrial transformations involve a broad spectrum of entrepreneurs across all places at each pace. The favourable examples are China's frontier green industrial transformations in which many SMEs and/or households in many regions and rural areas have rapidly, one after another, become entrepreneurs. China's high-speed railway industry is an instance of innovation-driven and greening high-road transformations without inclusive swamps of entrepreneurs. We extend this concept to scrutinise China's other socio-economic sectoral transformations that may help to improve inclusiveness to the broadest groups of participants although they may not now bring China to the frontier of inclusive competitiveness.

Primarily, the across-the-board diffusion of R&D-based industrial transformation among Chinese SMEs also denotes inclusive competitiveness. In this respect, the Chinese central and local governments have successfully pushed for innovation-driven transformations of SMEs, mainly with the innovation funds for supporting R&D and technology related activities of small firms, tax incentives for high- and new-technology enterprises located in high-technology SEZs and science parks, venture capitals, and seeding finances from state banks to innovative SMEs (European Commission, 2015). Most of the instruments have been used by SMES in the above transformations of renewable energy and other industries. Certainly, the latest forms of government funds that invested in venture capitals and start-ups in emerging industries also do the function. Typical process of government-led entrepreneurship begins with SMEs' R&D and technology investments coming from the supports of the governments and later from their reinvested profits. In the early 2010s, Chinese SMEs already appeared to be a key new driver for the augmented R&D expenditures, and their innovation output regarding introducing product or process innovations signposted that they appeared to perform better than those of the UK or Spain (Ibid.).

Apart from R&Ds, other S&T elements have been broadly employed on top of traditional economic transfer and social inclusion policies. The government's support to the agriculture sector has biggered since 2009 in terms of market price support, payments to farmers, support programs toward more sustainable and greener agricultural development (World Bank, 2017). Adding to that, the government setup the Agricultural Transformation Fund to support agricultural science and technology enterprises through research collaborations. By the end of 2013, the fund supported 6,386 projects which turned agribusiness to play a major role in technology innovation, promoted agricultural efficiency, increased rural incomes and trained new types of farmers and agricultural researchers (CAS, 2016). Respecting healthcare, access to healthcare has been enhanced by a dramatic expansion in health insurance coverage. From 2004 to 2014, the coverage rate increased from around 200 million to over 1.3 billion people, the largest expansion of insurance coverage in human history (OECD, 2017B). On top of that, the S&T Programme for Public Wellbeing with participations from local governments, enterprises and society has been applied immediately in poor areas to improve residents' quality of life. It has been constantly implemented and by 2014 resulting in employment of more than 100,000 pieces of innovative medical equipment and products and the propagation of more than 470 technologies, appraised to benefit 51 million people (CAS, 2016). Lately, the government has also initiated policies to improve equity in education and a fund guarantee system targeting rural compulsory education. Finally, the government support the diffusion of low-cost mobile phones among low-income groups. With the Golden Sun Project, the government has supported low-income groups to participate in the solar PV farming and industry (Ibid.).

Thailand's partial implementation of knowledge-based initiatives by limited high-road entrepreneurship

TNC- and large-firm-led industrial entrepreneurship and the government's fragmented R&D-based incentives and institutions

Thailand has transformed into the twenty-first century with increasing regulations, incentives and institutions for boosting R&D-based transformations. Unlike in China, however, the government has generally continued fending off directly command over the entrepreneurial function of commercialising knowledge for making industrial products and sectors. Additionally, only limited number of its state enterprises in the form of public companies, such as PTT group in petrochemical industries, have performed limited R&Ds (Asian Development Bank, 2015). Without government entrepreneurship, TNC and large domestic firms have provided industrial leadership in innovation-driven transformations. However, they have generally continued utilising mainly mature technologies, the more advanced of which have been imported, for upgrading production processes and products along their former low-road pathways in Thailand. Some behind-technology-frontier Schumpeterian innovations have been performed, but Thailand's overall innovation output remained moderate, ranked 45th in the world in 2018 below Vietnam which is ranked 41st though the former adds more innovation input (Cornell University et al., 2018). From 1996, TNCs, large firms and SMEs in Thailand have utilised scanty R&Ds for their industrial transformations though, among many fiscal and investment incentives, tax reduction of 200 percent (revised to 300 percent in 2014) for R&D expenses is much higher than the rate of 150 percent in China. Existing master plans, regulations and the National Science and Technology Policy Committee (NSTPC) have also failed to scale up R&Ds and frontier innovation within the country.

In the early 2000s, given that most R&Ds had been separately done in government research institutions and universities and not connected to industries, the government attempted not only to increase specialised R&D centres but also to intermediate these R&D performers with business firms. Under the first Five-Year Science and Technology Plan (2001-2006) and the Ten-Year Science and Technology Strategic Plan (2004-2013), the NSTPC was improved and chaired by the Prime Minister. The National Innovation Agency (NIA), R&D and innovation support funds and financing, science parks, venture capitals and business angels, and intellectual property system were developed and later extended their functions. A new government procurement law was issued. Registered patents and the importance of S&T and innovation have been persistently publicised. The 10th Five-Year National Economic and Social Plans (2007-2011) and its following ones have also highlighted innovation, social inclusion, environmental sustainability, and the role of S&T and R&D in driving them, for the country's development (UNCTAD, 2015). All reflect visions and initiatives just similar to those of China. The difference is simply the missing government entrepreneurship to command over the overall process of commercialisation of R&D-based knowledge in product and industry developments in Thailand. Also, without such high-road entrepreneurship from various domestic firms, the above regulations, incentives and institutions have failed to extensively uplift the country's overall R&D-based outcome competitiveness.

The key reasons for the failure include insufficient funding, deep-rooted weakness and fragmented functioning of the above mechanisms, and weak downstream demand for R&D and innovation (Intarakumnerd and Chaminade, 2007; Doner et al. 2013). In our framework, the inadequacy of government and/or private entrepreneurships to carry out R&D-based sectoral transformations is the key. Apart from the failure to exercise authority to command the above mechanisms, the government has also failed to utilise its specific industrial cluster initiatives to fulfil the transformations, given that the government leaders have only made discourse but not committed to command the overall transformation process (Intarakumnerd and Chaminade, 2007). The discourse and superficial hand-picked projects have been sporadically done in Thailand simply with populist political motives. Therefore, the leaders have left lower-level organisations patchily performing individual activities. Among these, the industrial technology assistance programmes

(ITAPs) of the National Science and Technology Development Agency (NSTDA), though with both successes and failures, have supported bridging somewhat more than 3,000 SMEs (in 4,200 projects) to research institutes and universities (ITAP, 2017). NIA has provided less supports (NSTDA, 2017). Yet, compared with the total number of about 3 million of overall SMEs reported by the government in 2018, the programmes are simply models of best practices. Furthermore, the programmes have mainly supported consulting, testing, and enhancing standards and technological capabilities with existing simple technologies and less degree of commercialisation (UNCTAD, 2015). They then serve as instruments to support inclusive development rather than global-frontier industrial transformation.

Nevertheless, the above fragmented high-road mechanisms implemented disjointedly by relevant organisations have brought about Thailand's improvement in S&T infrastructures and innovation enablers. As shown in Figures 1 and 2 above, these elements have pared with at least those of the lower bounds of advanced countries, although the competitiveness of Thailand in most of these elements has fallen and outpaced by China, from the WEF's report in 2006-2007 to that in 2017-2018. Again, our argument here is that low- and middle-income countries are practicable to build up the necessary S&T and innovation complimentary features, only that in this Thai case (without high-road industrial entrepreneurship) the matched R&Ds and the R&D-based transformations have not been successfully augmented and commercialised. Along this pathway, Thailand's overall R&D expenditures had crept up below 0.5 percent of GDP until 2014 before rising to 0.62 and 0.78 percent of GDP in 2015 and 2016, respectively. The rise in the last two years remains to be proved if it is because of the threshold effect of the increase in tax reduction for R&D expenses to 300 percent, of the government's innovation-driven Thailand 4.0 Policy propagated since 2015, or of the changing behaviours of some large firms in some industries towards the importance of R&D in augmenting competitiveness.

Thailand's limited industrial upgrading on its previous low-road industrial pathway

Presently, leading industries in Thailand, notably electronics, automobiles, petrochemicals and processed foods, have maintained their low-road competitiveness by former TNC- and large-firm-led entrepreneurships, which have participated in upgrading their technologies and coupled organisational and human technological capabilities within their production networks. As mentioned above, certain degrees of improvement (though with fragmentation) in regulatory, incentive and institutional instruments as well as S&T and innovation enablers have not driven Thailand's production bases to the full R&D-based high-road pathway. Like those in China in the early 2000s, joint-venture TNCs in Thailand's electronics and automobile assembling industries have been reluctant to transfer frontier but mature parts of technologies to Thai producers, which are mostly SMEs and second- or third-tier suppliers and part producers. With low technology spillovers to domestic producers, TNCs have locally performed limited R&Ds in materials development, vehicle testing and design. The Thai firms have had to pay huge amount of fees for consulting, technical services, royalties and licenses used for part production (UNCTAD, 2015), revealing that their technological levels have remained short.

Certain Thai automotive suppliers have performed limited R&Ds as absorptive capacities; some have coordinated with local universities, for developing original design manufacturing (ODM) parts for supplying TNCs and exports (Intarakumnerd et al., 2012). Supporting Thailand's automobile industry to become the 12th largest world producer (Asian Development Bank, 2015), however, Thai producers have had no entrepreneurship to invest in R&Ds and related capacities that tie to frontier technologies. In the high-tech hard disk drive subsector which has been the 2nd largest global production base, TNCs have dominated overall production networks and still imported most of high-value parts. Thai producers have had less chance to engage in the higher-value R&D and design activities of product development (Ibid.). In the semiconductor subsector, government research institutes and agencies and industrial associations have intermediated R&D performers, local universities, with producers. However, R&D bases have been used locally up to the level of design and ODM activities. Local producers' transformation to higher parts of the value chain then needs purposeful engagement in higher levels of R&D that connect to frontier technologies and starting upstream companies (Intarakumnerd et al., 2016).

Contrary to the upside limits exerted from TNCs' production networks, there exist limits related to the scale and the diffusion of indigenous high-road entrepreneurship in Thailand's leading petrochemicals and processed foods industries. In both, not many large domestic firms, such as PTT group, SCG group, CP group and Mitrphol group, have expanded R&D bases to continue augmenting their competitiveness and compete globally (UNCTAD, 2015; World Bank, 2018), but the majority of firms have stayed on their low-cost and –price competitiveness. The large firms are the core behind Thailand's improvements in WEF's competitiveness ranking related specifically to company spending on R&D and university-industry collaboration in R&D. However, the latter practice has remained sporadic, without formal arrangements (Doner et al. 2013). Only in the petrochemical subsectors that some of the above large firms make up most of local market share have been intensively upgraded by R&Ds. One of these, the ethylene subsector is among the top sixteen in world market and a closed follower of market leaders. However, though augmenting its R&Ds as absorptive capacities, the oil and gas subsector has remained accountable for balance of payment deficits in consulting and technical fees (UNTAD, 2015). For the rubber and plastic product subsector where SMEs prevail, the R&D-based strategy stays to be pushed for. This subsector and the chemical products subsector have also continued registering trade deficits.

Like a few of those in the petrochemicals industry, some large firms in the processed foods industry have upheld their R&D institutes for incrementally upgrading their technologies. This has supported Thailand's position as a world-leading foods exporter in many categories. However, when requiring more advanced technologies, the large firms have temporarily turned to universities and government research institutions for assistances (Doner et al. 2013). This reflects that some large firms have yet to upgrade their own R&D activities or systematically connect to higher educational and research institutions to approach frontier technologies. Meanwhile, the majority of the producers in the industry are SMEs, which have not yet participated in diffusing the R&D-based competitive strategy. Attempting to proliferate such strategy under Thailand 4.0 Policy, the government has recently stretched R&D networks and infrastructures for food producers within

Food Innopolis in Bangkok Science Park. From NSTDA's innovation surveys between 2008 and 2016, food products led other industries performing an average of 16 percent of total business R&D, and together with motor vehicles, office and computing machinery, and wholesale/retail industries the industry significantly increased their R&Ds in 2015 and 2016. As mentioned, however, the rises in R&D in the last two years remains to be proved for their links with increased fiscal incentives or the overall Thailand 4.0 Policy. This is because other key R&D performers including petroleum products, chemical products, machinery and equipment, and rubber and plastic products industries, which have performed the averages of between 4 and 13 percent of total business R&D, significantly decreased R&D activities in 2015 and 2016 (NSTDA, 2017).

Comparative sustainable and inclusive transformations

While China has made much progress in sustainable and inclusive transformations, Thailand has remained unsuccessful in implementing many of the consecutively issued regulations and incentives. Just as in the industrial transformation case, without entrepreneurship to commercialise and/or implement specific knowledge, plans and strategies and combined elements related to sustainability and inclusiveness, they are simply left at the institutions that produce them. Green transformation has then been very slow in Thailand although the government has lately issued the Energy Efficiency Development Plan (2011-2030) and the Renewable and Alternative Energy Development Plan (2012-2021) and has targeted for reductions in emissions and energy intensities as well as the increase in demand from renewable energy (OECD, 2013, World Bank, 2016). On the inclusive front, in addition to the above small-scale ITAP programmes, Thai poor households has been also supported by the late King's self-sufficiency programmes, utilising existing knowledge (and limited R&D) for innovations that only sustain income and fitting with surrounding environment. It is the open middle road to self-stabilise income and livelihood amid economic fluctuations, but not for expansion or growth. Only thousands of his projects successfully adopted along the pathway that supports the poor, but the later supports of the Thai government under Ministry of Interior could not scaling them up. It is now superficially carried out by limited budgets. At this end, we then simply utilise WEF's 2017-2018 IDI data to rank and compare high-road inclusive and sustainable outcomes of Thailand with China and 30 advanced counties, as shown in Table 3.

According to the table, which ranks the countries based on employment (%), poverty rate (%), wealth Gini, net income Gini, ecological-adjusted net savings (%), public debt (%), dependency ratio (%) and carbon intensity (kg per $ of GDP), both China and Thailand perform thriving in ranks at the frontier of sustained employment and low poverty and dependency rates. They are ranked slightly high pertaining net environment-adjusted savings and public debts, but at the bottom ranks respecting carbon intensity and inequality. The favourable developments in employment, savings and poverty reduction of the two countries are inclined growth driven. The relative poor performances of China and Thailand in net income Gini category reflect the ineffectiveness of the Chinese and Thai governments' fiscal policies in addressing inequality (World Bank, 2016; 2017). In addtition, Figure 3 above also illustrates that from 1990 to 2014 Thailand has failed but China has highly succeeded reducing carbon intensity per GDP.

Rank	Employment rate	Poverty rate	Wealth Gini	Net income Gini	Adjusted net savings	Public debt	Dependency ratio	Carbon intensity
1	Iceland	**Thailand**	Slovak Republic	Iceland	Singapore	Estonia	Korea, Rep.	Switzerland
2	**Thailand**	Denmark	Iceland	Norway	Ireland	Luxembourg	Singapore	Sweden
3	**China**	Czech Republic	Slovenia	Denmark	**China**	New Zealand	**China**	Norway
4	Singapore	Finland	Estonia	Czech Republic	Luxembourg	Spain	**Thailand**	France
5	Switzerland	Iceland	Japan	Finland	Norway	Norway	Slovak Republic	Denmark
6	New Zealand	Switzerland	Belgium	Sweden	Sweden	Czech Republic	Luxembourg	Ireland
7	Norway	Netherlands	Czech Republic	Belgium	Korea, Rep.	Korea, Rep.	Canada	Iceland
8	Australia	Sweden	Australia	Slovenia	Denmark	Denmark	Switzerland	United Kingdom
9	Canada	Luxembourg	Spain	Slovak Republic	Switzerland	Australia	Austria	Austria
10	Israel	Norway	Italy	Netherlands	Israel	Sweden	Slovenia	Italy
11	Sweden	France	Greece	Austria	Netherlands	**Thailand**	Australia	Finland
12	Netherlands	Slovak Republic	Luxembourg	Luxembourg	**Thailand**	Switzerland	Czech Republic	Spain
13	United Kingdom	Austria	Switzerland	Germany	Iceland	**China**	Spain	Japan
14	United States	Belgium	Korea, Rep.	Switzerland	Germany	Slovak Republic	United States	Luxembourg
15	Korea, Rep.	Ireland	France	France	Austria	Iceland	Greece	Portugal
16	Denmark	Slovenia	Portugal	Japan	Estonia	Israel	Iceland	New Zealand
17	Germany	Germany	New Zealand	Ireland	New Zealand	Netherlands	Germany	Netherlands
18	Estonia	New Zealand	Netherlands	Korea, Rep.	Slovenia	Finland	Norway	Belgium
19	Japan	United Kingdom	Singapore	Canada	Belgium	Germany	Netherlands	United States
20	Czech Republic	**China**	Canada	New Zealand	Australia	Ireland	Portugal	Greece
21	Austria	Estonia	United Kingdom	United Kingdom	United States	Slovenia	New Zealand	Estonia
22	Luxembourg	Canada	Israel	Australia	Finland	Austria	Belgium	Slovenia
23	Ireland	Australia	Finland	Italy	France	United Kingdom	Ireland	Slovak Republic
24	Slovak Republic	Portugal	Austria	Spain	Spain	Canada	Estonia	Canada
25	Finland	Italy	**China**	Estonia	Japan	France	United Kingdom	Australia
26	Slovenia	Korea, Rep.	Germany	Portugal	Canada	Belgium	Denmark	Germany
27	Portugal	Greece	Norway	Israel	Czech Republic	United States	Italy	Korea, Rep.
28	France	Spain	Denmark	United States	Slovak Republic	Singapore	Finland	Israel
29	Belgium	Japan	Ireland	Greece	United Kingdom	Portugal	Sweden	Czech Republic
30	Spain	United States	Sweden	Singapore	Italy	Italy	France	Singapore
31	Italy	Israel	**Thailand**	**Thailand**	Portugal	Greece	Israel	**Thailand**
32	Greece	N/A	United States	**China**	Greece	Japan	Japan	**China**

Table 3. *Inclusive and sustainable development ranking of China, Thailand and advanced countries, 2017-18*

Source: World Economic Forum (WEF) Inclusive Development Data.

Conclusion and implications

With the definition that the high-road policy comprises strategies for engendering sectoral transformations with innovation-driven economic dynamics, social inclusiveness, and environmental sustainability, we here have China as an example of middle-income country that practicably increases its competitiveness by leapfrogging to adopt full-bodied high-road strategies while Thailand can only accomplish part of the strategies to fulfil its poverty reduction goal. The theoretical and policy contributions of this paper are related to the fact that the two countries have added the high-road strategies on top of their continued low-road strategies, in expecting for enlarged competitiveness and socio-eco-economic values from both strategic choices. In policy space, this study prompts developing countries of expanded opportunities in augmenting competitiveness from such hybrid policy mixes and reminds advanced countries of such intensified competition. In detail, an extended Schumpeterian framework has been employed to investigate industrial, sustainable and inclusive transformations in the two countries. We conceptualise and use stylised facts to prove that such transformations require a transient Schumpeterian entrepreneurship or leadership that must compose not only of "foresight" and "initiative" but also and mainly of "authority" to interactively persuade, push or force the adoption and diffusion of "new combinations" of components of sectoral transformations. As evidenced for China and

Thailand, sole visions, plans, regulatory and incentives are not sufficient for making high-road transformations. The high-road transformations involve entrepreneurship in executing or commercialising R&D-and S&T-based knowledge for innovations or new combinations of frontier industrial transformation, competitive ecological sustainability and/or increased socio-economic inclusion.

Generally, the findings underline China's Schumpeterian-typed government-led entrepreneurship in successfully combining R&D- and other-knowledge-based policies with other conventional industrial policies and elements, for global-frontier industrial and green transformations and competitively inclusive sectoral development. Voluminous global-frontier industries including renewable energy and green industries are solid evidences of "outcome competitiveness" of such high-road industrial and green transformations. However, the high-road industrial transformation has progressed over China's presently competitive low-cost industries and its green industrial transformation has been on top of the government's expansive spending, institutional setting, and stronger regulation and incentive to support the increasingly market-driven energy efficiency development. As well, China's other knowledge-based (including partial S&T-based) income and wellbeing uplifting programmes have provided beneficial effects on agricultural and entrepreneurial productivity and income of farmers, SMEs and low-income groups, and on poverty reduction. This has been simply added to the effects of China's continued economic growth on poverty reduction although they have not been accompanied by improved wealth and fiscal-adjusted income inequality. Policy implications from the Chinese case are then evidently not about selecting between market-, incentive- and regulatory-based policies and other interventionist and deliberative policies, but about hybrid mixes of them.

For Thailand, the inadequacy of dominant domestic- but TNC-led entrepreneurships for commercialising R&D bases in frontier industrial transformations has kept the country sluggishly upgrading the still-competitive industries created during the low-road transformations. Limited R&Ds have been performed by certain TNCs and large firms merely for such upgrading purpose. Considerable biotechnology and agricultural R&Ds by specific research institutions (UNCTAD, 2015) have remained detached from opportunities for scaling industrial and renewable green transformations. With the failures of its numerous incentive, regulatory and institutional mechanisms to improve energy efficiency but limited environmental protection, sustainable transformations in Thailand have been lagging. Comparable to China's inclusive transformation is Thailand's knowledge-based (including partial R&D- and S&T-based) inclusive transformation through income and wellbeing uplifting programmes, which have sustained, with certain growth of, incomes of farmers, SMEs and low-income groups and helped to reduce poverty. Here is also the case of adding to the effects of the country's economic growth (which is now comparatively low) on poverty reduction, and the transformations have been accompanied by neither improved wealth nor fiscal-adjusted income inequality. Apart from how Thailand has failed to obtain successful high-road industrial and sustainable transformations, however, we may learn about one inclusive transformation. It is related to the role of Thailand's science, technology and innovation institutes that, though failing to scale up frontier industrial transformation, support the utilisation of S&T to sustain productivity and income of SME and community enterprise niches, which have not received typical supports from domestic and global production networks and value chains.

At the core of this paper, what can be learned from the utilisation of R&D-based high-road industrial policy for augmenting competitiveness is not the gigantic escalation of R&D investment, such as that has happened in China, but its fitting combinations with other industrial policies and elements. Matched human and organisational technological capabilities and new-demand management, in the forms of new product and service procurements, market protection, or subsidised exports, have been evidenced in all above successful frontier industrial transformations. Price subsidies and physical infrastructure supports have been also found, especially for the green industrial and inclusive transformations of China. Note that in our Schumpeterian framework as evidenced by the case of China, the combinations of the R&D industrial policy with other complimentary components are feasible for leading entrepreneurship because the components and their practicable substitutes can always be created. For some other low-income beginners this may simply take longer time. Big and rich countries or firms with leading entrepreneurship naturally do so while smaller and poorer countries or firms learning to carrying out such industrial policy mixes as followers can also afford creating both R&D investment and matched components, though with extended time. Common complementary factors swiftly adoptable includes fiscal incentives, price subsidies, market protection and certain procurements which many countries regularly implement. Accordingly, the stylised facts in this study refute conventional studies arguing that weak quality of complimentary factors such as education and the qualities of scientific infrastructure and the private sector, which usually coincide with the poorer countries farther away from the frontier, are causes of lower utilisation of R&D for catching-up (e.g. Goñi and Maloney, 2014). In contrast, as illustrated in Figurea 1 and 2, Thailand has in the 2000s developed stronger qualities of the R&D complementary factors to the level compared to some advanced countries, but has continually done only small amount of R&D in both absolute and per-GDP terms. What is missing in Thailand are leading (and clusters of following) private or government entrepreneurships to scale up R&Ds and combine them with other complementary elements for the frontier innovative-driven industrial transformation. Finally, the high-road industrial policy and its outcome competitiveness, especially those we learn from China, need not to be in stage-by-stage pathway or perfect, balanced development. Adaptive experimentations, with trails and errors, catchingups and leapfroggings, successes and failures, are usual under the uncertainty ingrained in the process of sectoral transformation. Entrepreneurship and its diffusion are required for propelling new combinations of such competitive structural change.

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