Chapter 2

Electric Vehicle and Electric Vehicle Component Production in Thailand

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CHAPTER 2

ELECTRIC VEHICLE AND ELECTRIC VEHICLE COMPONENT PRODUCTION IN THAILAND

Martin Schröder

1. Introduction

Whilst other countries or regions, such as Mexico, Turkey, and Central or Eastern Europe, have attracted more scholarly attention as newly integrated peripheries of the global automotive industry (Frigant and Layan, 2009; Özatagan, 2011; Pavlinek and Zenka, 2011; Pavlinek, 2017; Brincks et al., 2018), Thailand has also established itself as a global production and export hub. It has done so largely by deploying a similar set of policies as these countries, i.e. deregulation, integration into production networks dominated by foreign firms, and the provision of investment incentives.

As technology in advanced and in some emerging markets, especially China, is slowly shifting towards electric vehicles (EVs), Thailand's position seems to be threatened by this development as future production will require skills and know-how differing from present standards.

Against this background, Thailand recently initiated policy to support local EV and EV component production. This chapter will investigate the country's current position in EV supply chains, the Thai automotive sector policy, and policy outcomes. The study adopts a historic perspective in that it incorporates not just recent policy but reviews past policy as a framework to understand recent measures. It will be argued that continuing to implement industrial policy along lines that proved to be successful in the past may no longer be appropriate as technology shifts, and suggests that tools may have to be repositioned towards more encompassing innovation policy.

This chapter is structured as follows. A brief review of the difference between industrial and innovation policy will be conducted as well as a review of different explanations of Thailand's successful transformation into a global production and export hub. Subsequently, a review of the trade data will be conducted to assess Thailand's current position in EV supply chains. However, as trade data lack the sufficient level of disaggregation, this step will be supplemented by an analysis of the supply chain for lithium ion (Li-ion) batteries, the most promising EV-grade traction battery subtype. This will be followed by an analysis of the past and present automotive policy as well as an attempt to evaluate the policy success (or lack thereof). Finally, some conclusions regarding the present policy, especially concerning the main policy tool, will be drawn.

2. Literature Review

2.1 Industrial policy and innovation policy

Targeting is a well-known and controversially discussed industrial policy practice. Linked to Johnson's (1982) seminal study of Japanese industrial policy, targeting means that policymakers strategically employ measures, such as preferential loans, tax breaks, accelerated depreciation, informal steering of production quantities, export promotion, and import restrictions, to nurture selected industrial sectors. Whilst targeting is frequently mentioned by Johnson, it is subsumed under what he termed administrative guidance. Arguably, the term administrative guidance better describes the nature of political and/or bureaucratic intervention than targeting because it highlights that the state needs cooperation from privately owned enterprises to achieve targeted objectives. The automotive industry provides several cases that illustrate how targeting did not work if the state attempted structural intervention in a growing industry: Japanese bureaucrats could neither hinder Honda from entering automobile production nor consolidate the 10 independent Japanese original equipment manufacturers (OEMs) into two groups centred around Toyota and Nissan (ibid: 277). Whilst targeting worked in cases where industries were experiencing downturns, Japanese policy could never prohibit entry into growth sectors.

Similar to industrial policy in general (Pack and Saggi, 2006), targeting has received significant critique, especially from orthodox economists. Beason and Weinstein (1996) pointed out that not growing but struggling sectors of the Japanese economy were subject to most targeted assistance, concluding that policy either performed poorly at targeting growth sectors or intentionally supported declining sectors, which contradicts developmental state literature. Simultaneously, it is worth noting that even critics who argue that targeting broke down in the 1970s or 1980s, do not deny positive impacts of Japanese industrial policy before this time (Callon, 1995: 4). Further, Johnson (1999: 54–56) later qualified his argument for targeting and the developmental state by pointing out that it may time-specific in two regards. First, during much of the Cold War era, the United States (US) tolerated protectionists' practices to support allied states economically. Second, countries such as Japan were catching up to more advanced economies, i.e. choosing target industries revolved around emulating existing industrialisation trajectories but speeding up development through various state interventions.

During the 1990s, it was observed that relatively broad industry targeting shifted towards more focussed technology targeting (Chiang, 1993). Lately, several researchers (Soete, 2007; Vorley and Nelles, 2010) have observed industrial policy increasingly shifting towards innovation policy. Soete (2007) emphasises that this entails a significant broadening of policies, i.e. industrial development is no longer framed within the context of firms that constitute an industrial sector but incorporates questions of (higher) education, research capacity, geographic proximity (or embeddedness), and what Cohen and Levinthal (1990) christened absorptive capacity.

2.2 Thailand automotive policy: Targeting, clustering, and liberalisation

Thailand has been recognised as a successful case of integration into global automotive supply chains and the resulting relatively strong competitiveness. When it comes to explaining how Thailand positioned itself as a global export hub, several factors have contributed to this achievement.

Firstly, Thai policy strongly focussed on promoting one particular type of vehicle, namely the one-tonne pickup truck. It should be highlighted that this occurred before and after deregulating protective measures, such as foreign ownership restrictions and local content requirements. Policy encouraged the manufacturing of one type of vehicle, the so-called 'product champion', by providing incentives for producers and Thai consumers (Natsuda and Thoburn, 2013). By including incentives for components specifically used in one-tonne pickup trucks, Thai policy aimed at localising a significant part of the supply chain in order to capture value-added in manufacturing. It should be pointed out, that focussing on one-tonne pickup trucks was by no means accidental but rather a continuation along a long-established trajectory of Thai industrialisation policy. This particular vehicle type captured roughly 50% of the local market during the 1980s and has been the target of dedicated import substitution policies, such as a series of projects aiming at the rationalised, local production of diesel engines (Doner, 1991: 202–218). Obviously, the product champion approach is a variant of technology targeting because policy promoted a narrowly defined type of vehicle for local production. Thailand's success in applying this strategy suggests that targeting can still be utilised within an increasingly restricted policy space.

Secondly, deregulation before the Asian financial crisis (AFC) attracted foreign automotive firms to Thailand. In 1993, Thailand announced that it would abolish both foreign ownership restrictions and local content requirements (LCR) by 1997, i.e. before this was ruled out by the World Trade Organization (WTO). This step made investing in Thailand more appealing in comparison to competing ASEAN countries which continued these practices (Warr and Kohpaiboon, 2017). The impact of deregulation is, however, not undisputed. First, it has been claimed that carmakers nolens volens redirected production capacities towards exports to overcome the implosion of the Thai market (Edgington and Hayter, 2001). Lauridsen (2004) demonstrated, however, that especially Japanese small and medium-sized enterprises from the automotive as well as electric and electronic industries invested in Thai operations before the crisis broke out. This tendency was strongly supported by carmakers. Whilst Kohpaiboon (2009) stressed increased foreign direct investment (FDI) inflows after the crisis started, he also reports considerable growth of production capacity in Thailand before it hit the country. Thus, carmakers clearly began encouraging the foundation of a deepened local supply chain in Thailand well before the crisis, although it is noteworthy that they invited Japanese suppliers rather than engage Thai suppliers to develop deepened production capabilities. If one keeps in mind that liberalisation was announced well before the crisis, this tendency cannot be overly surprising because Thailand provided a more attractive business environment than neighbouring car-producing countries, such as Indonesia and Malaysia. Second, several researchers (Wad, 2009; Athukorala and Kohpaiboon, 2010; Warr and Kohpaiboon, 2017) described deregulation as wholly positive and doubt the positive role of the LCR in promoting Thai participation in the supply chain. Warr and Kohpaiboon (2017: 5) argued that many Thai firms were eliminated from competition after liberalisation and that increased exports should be attributed to newly created FDI parts suppliers and new Thai firms. Whilst this is plausible, they do not present any conclusive evidence to support their claim. Nevertheless, it is plausible that only the most competitive Thai suppliers survived the double impact of the AFC and liberalisation. Also, it should be noted that even before the AFC occurred, local sourcing was mainly achieved through reliance on FDI suppliers. In the case of Toyota, it has been reported that local content was 50% in 1996, with 70% of these parts being supplied by Japanese suppliers, 20% from firms who received Japanese (technical) assistance, and only 10% from Thai firms which did not receive any form of assistance (Guiheux and Lecler, 2000: 211). Third, Hassler (2009: 2237) pointed out that Thailand's abolition of national LCR should not be overemphasised since LCR partly remained in place in the form of regional LCR under the ASEAN Free Trade Area. He also emphasised that around 1,700 parts suppliers had been established during the LCR era. Whilst the number of parts suppliers in Thailand greatly increased during the post-liberalisation era to around 2,400 firms in 2014, this should not be regarded as evidence that LCR did not provide opportunities for local firms to join supply chains. Undoubtedly, however, there are clear qualitative limitations towards supply chain participation. Today, Thai-owned enterprises tend to be confined to the supply of less technologically sophisticated, non-functional components, whereas functional, higher value-added components are mainly produced by foreign-invested enterprises (Intarakumnerd and Charoenporn, 2015: 1317).

Thirdly, Thailand proactively engaged in the creation of infrastructure and industrial clusters, most notably the so-called Eastern Seaboard. Infrastructure development was supported for several reasons. First and foremost, Bangkok was not accessible for large, ocean-going container vessels, so locating export-oriented manufacturing in Bangkok did not make economic sense. Further, Bangkok was already suffering from traffic congestion, so additional manufacturing investment and related supply chains would arguably worsen the logistical situation. Indeed, traffic congestion was perceived so critical that it was ranked third amongst issues that firms wanted to be addressed by government policy in a survey investigating business conditions in Bangkok (Tsuji et al., 2008: 221). Moreover, providing modern infrastructure alone should attract export-oriented FDI as such infrastructure can reduce various costs related to transport and communication. Regarding the Eastern Seaboard, it is well documented that Thai policies provided strong incentives to promote industrial agglomerations in the region in order to avoid overconcentration in and around Bangkok. As a result, FDI increasingly located production in targeted areas, which means that the original concentration of the automotive sector in Bangkok and Samut Prakan was reduced as Eastern provinces, such as Chachoengsao, Chonburi, and Rayong, attracted new investments (Lecler, 2002; Kuroiwa and Techakanont, 2017). Geographic clustering was pursued to enable low-cost logistics for delivery under just-in-time supply chain arrangements prevalent in the automotive industry.

Despite some shortcomings, Thailand is nevertheless considered as a case of successful industrial development. Lately, South Africa, an example of a developing country, seeks to learn from Thailand's experience in order to emulate its success (Barnes, Black, and Techakanont, 2017; Monaco, Bell, and Nyamwena, 2019). Thailand's success in becoming a global production and export hub is only overshadowed by Mexico, whose geographic location has enabled a strongly symbiotic relationship with the US automotive industry. Lacking such favourable geography, the Thai case is all the more remarkable as it lacks direct access to a large, wealthy consumer market.

Whilst Thailand's current position in the global automotive industry and supply chain is well understood, what are the potential consequences of a shift towards EVs? Before turning to this question, it should be highlighted that only general implications will be analysed, that is implications for the potential role of Thai firms in the supply chain will not be investigated in detail. However, the aforementioned confinement to non-functional parts (Intarakumnerd and Charoenporn, 2015) suggests that incumbent Thai suppliers may not be strongly affected as functional internal combustion engine vehicle (ICEV) components, such as engines and transmissions, which are no longer used in fully electric types, are dominated by foreign suppliers. Nevertheless, this confinement does not necessarily mean that Thai suppliers may not be significantly affected. As EVs will require several technological improvements to become competitive vis-à-vis ICEVs, pressure to reduce component weight or decrease components' electricity consumption is encompassing the whole automotive supply chain. Thus, Thai suppliers may encounter challenges indirectly related to electromobility.

3. Thailand's Position in the Electric Vehicle Supply Chain

3.1 Trade data review

Whilst Thailand is the centre of the automotive industry in the ASEAN region and a global export hub for one-tonne pickup trucks, does the country play a role in the supply chain for EVs?

To answer this question, attention should first be focussed on battery trade. As batteries are used in all EV types under investigation and are a key component, exploring Thailand's ability to export may provide some indication about its position in the EV supply chain.

Answering this question is not easy as the available statistical data obscure important details. Trade data recorded under the UN Comtrade database organised according to the six-digit Harmonised System (HS) code do distinguish between different battery types (primary or secondary) and according to differences in cell chemistry, but do not specify applications, e.g. for use in EVs or consumer electronics. Thus, the reported data must be interpreted with caution. Further, the HS code allows differentiation between battery packs on the one hand and modules and cells on the other (Table 1).

Table 2.1: Thai Trade in Battery Types and Components in 2019

HS Code	Covered Items	Imports (in US$ million)	Global Rank	Exports (in US$ million)	Global Rank
8507.10	Lead-acid starter battery	54.3	31	197.7	12
8507.50	NiMH battery pack	21.0	17	0.1	39
8507.60	Li-Ion battery pack	122.5	30	8.4	33
8507.90	Battery modules, cells, and components	110.0	9	112.2	6

HS = Harmonized System, NiMH = nickel metal hydride.
Source: UN Comtrade.

First, the data indicate that Thailand has a strong position in conventional starter battery production and exports. Second, in terms of trade value, nickel metal hydride (NiMH) batteries are not a significant item. This may be due to the fact that this battery type is not widely used compared to others. However, NiMH batteries must be addressed as they have been used in many hybrid electric vehicles (HEVs), most notably the Toyota Prius. The rather low HEV production volume (see below), however, suggests that local NiMH battery production may be dedicated for other applications. Third, a significantly higher import than export value for Li-ion batteries suggests that Thailand does not play a significant role in the global supply chain for this type of battery. As Li-ion batteries are used for many applications, most notably consumer electronics, drawing conclusions about the EV supply chain is not possible. Fourth, apart from the issue that the data do not specify use, the rather strong position in battery components must also be interpreted carefully. As the subheading covers the components of all battery types reported in other subheadings, the actual nature of imported and exported components is unclear. Thus, it may be possible that Thailand imports mainly components for advanced types, such as EV traction batteries, but exports components of standard types, such as vehicle starter batteries. As more than 95% of Thai battery components are imported from Malaysia, the former assumption appears somewhat unlikely. However, as more than 95% of Thailand's battery components are exported to Viet Nam, the latter assumption appears at least plausible.

Regarding other EV components, the available trade data also lack the level of disaggregation to allow a detailed exploration of Thailand's positioning inside EV supply chains. Regarding electric motors, only the level of electrical output is indicated but not the specific applications, such as for aircraft, EVs, or power electronics. Thus, the data can only provide an approximate idea of the extent of the role Thailand may play in EV supply (Table 2).

Table 2.2: Thai Trade in Electric Components in 2019

HS Code	Covered Items	Imports (in US$ million)	Global Rank	Exports (in US$ million)	Global Rank
8501.32	Electric motors, output 750W–75kW	6.7	34	1.7	35
8501.33	Electric motors, output 75kW–775kW	0.6	45	3.6	19
8504.40	Electrical static converters	501.4	27	1,336.1	8

kW = kilowatt, W = watt.
Source: UN Comtrade; accessed 1 June 2020.

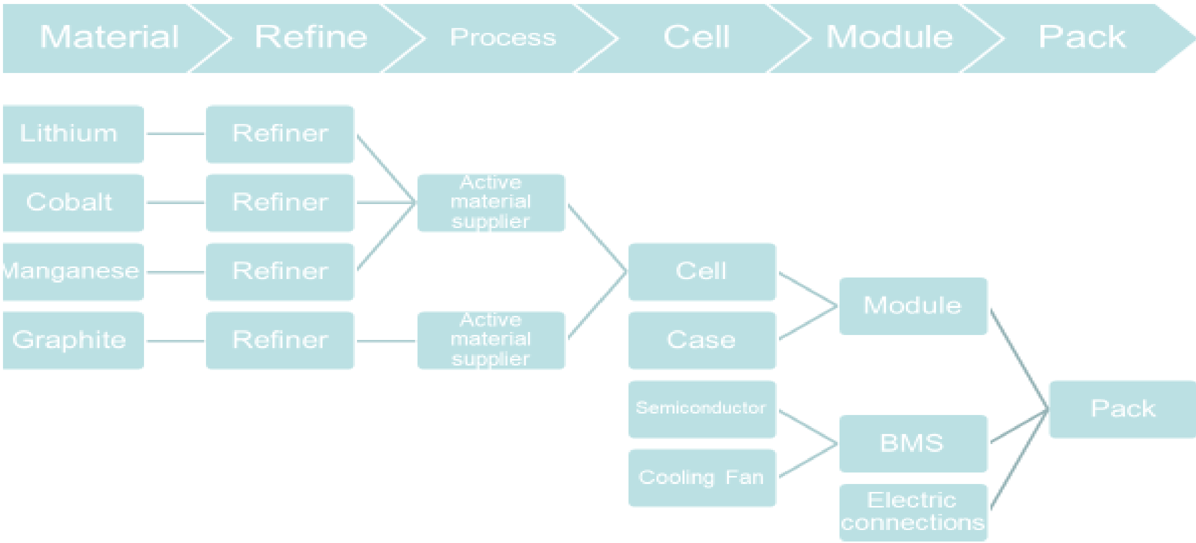
With due caution, it can be stated that Thailand has a relatively strong export position in some EV-related components, such as electric motors as well as converters and inverters, suggesting that local sourcing for EV production and participation in the EV supply chain may be possible.

Overall, the trade data only provide a limited insight due to a lack of disaggregation that could represent complexity at the product level. Therefore, it can only be stated that Thailand may be in a position to locally produce and export components such as electric motors, converters, and inverters, including parts thereof. When it comes to batteries, the lack of disaggregated data and multi-use battery types only allow for the general observation that Thailand is currently not a significant exporter of battery types relevant for EV production.

3.2. Supply chain analysis

As trade data do not provide conclusive information about Thailand's position in the evolving EV supply chain, it was decided to analyse the Li-ion battery supply chain to get a clearer picture. To break down the supply chain, the stages outlined in the framework for the overall project were applied (Figure 1).

Figure 2.1. Lithium-ion Battery Supply Chain



Source: Based on the author's investigation.

To gain an understanding of the parts of the supply chain Thailand participates in for Li-ion batteries, which are regarded as the dominant type of EV batteries, the global production footprint of major industry players was analysed based on publicly accessible information from industry publications, the online journal *InsideEVs*, Thai newspapers *The Nation* and *Bangkok Post*, as well as company websites.

At the time of writing, only a single company is conducting EV-grade Li-ion pack, module, or cell production in Thailand (see below and Appendix). Whilst several other companies plan to establish production in Thailand, it appears that projects will start at the pack stage. Thus, when it comes to battery production, it appears that Thailand will only serve as an assembly location that produces modules and packs from imported cells. This suggests that local value-added will be rather low.

When it comes to so-called active materials, i.e. those materials that are processed[24] into the cathode, anode, electrolyte, and separator, Thailand plays no significant role. However, it should be pointed out that this part of the EV battery supply chain is highly specialised and dominated by a few firms that mainly hail from China, Japan, or the Republic of Korea. Indeed, research conducted on behalf of the US government found that these three countries have established production capacities for particular active materials that form strong national supply chains and explain strong export performance (Sandor et al., 2017). Thus, Thailand's absence from this particular link in the Li-ion battery supply chain cannot be surprising as only a limited number of firms from a few countries have established themselves as strong players.

As for the raw materials used in Li-ion battery production, Thailand is neither a significant source nor a user (Table 3).

[24] Processing generally occurs during the cell production stage – cathodes and anodes are made from pre-processed materials that usually are in powder form. However, materials may also be delivered in large rolls, so the electrodes are merely cut into shape and further processed. Electrolytes are produced by mixing salts containing lithium with solvents to form liquid solutions or gels.

Table 2.3: Thai Trade in Raw Materials Used in Lithium-ion Batteries in 2019

HS Code	Covered Items	Imports (in US$ million)	Global Rank	Exports (in US$ million)	Global Rank
2825.20	Lithium oxide and hydroxide	4.3	15	0.0	25
2836.91	Lithium carbonate	1.1	22	0.6	16
2605.00	Cobalt ores and concentrates	0.0	21	0.4	6
8105.20	Cobalt; mattes and other intermediate products of cobalt metallurgy, unwrought cobalt, powders	9.1	20	0.2	29
2504	Graphite; natural	4.2	18	0.0	29
2602.00	Manganese and concentrates	6.2	22	12.4	13
2604.00	Nickel ores and concentrates	0.0	17	0.2	22

HS = Harmonized System.
Source: UN Comtrade; accessed 1 June 2020.

Regarding the marginal raw material exports, this does not necessarily mean that the country does not possess any deposits. Potential raw material deposits may be too expensive to be extracted at current market prices. Regarding the limited raw material imports, this may indicate a lack of a processing industry that can engage in the refining of industry-grade materials. These findings are consistent with a recent analysis of potential material supply shortages in the Li-ion battery supply chain (Olivetti et al., 2017) that reviewed raw material extraction and processing. Whilst other ASEAN countries such as Indonesia and the Philippines are mentioned as important global sources of nickel, Thailand is not mentioned once in the analysis. Thus, it can be concluded that Thailand currently is not a significant source of raw or intermediate processed materials for Li-ion battery production.

4. Thai Automotive Industry Policy and Vehicle Production

According to the International Organization of Motor Vehicle Manufacturers (OICA), Thailand was the world's eleventh-biggest vehicle producer in 2019, documenting its position as ASEAN's leading vehicle manufacturing country. Thai EV support is apparently aiming to secure the country's current position in regional and global production networks. Following the underlying assumption that EVs are the future of the automobile industry, Thai policy is seeking to manage the technological transition. Thus, as will be shown below, policy not only addresses consumers and producers but also the local production of specific EV components.

This section will introduce overviews over several generations of product champion policies towards the automotive industry in Thailand. Policies aimed at the automotive industry can be divided into different phases. Researchers who have developed explicit chronologies of Thai automotive industry history (Natsuda and Thoburn, 2013; Kuroiwa and Techakanont, 2017) have tended to distinguish between five different phases which, however, differ in detail. For the purpose of this investigation, it appears unnecessary to reiterate the historic development of the automotive industry in Thailand. Instead, the study will focus on policies that have been developed during the latest stage of industry development, which is said to have occurred after the year 2000.

As aforementioned, the main policy aim of the consecutive automotive sector policies was to promote Thailand as a regional, ideally global, export platform. Given this aim, production figures, as well as foreign investment into production, may be regarded as indicators for the success or failure of these industrial policies. Therefore, the available data will be reviewed in order to evaluate the impact of sectoral policy.

4.1 One-tonne pickup trucks: Emergence of the product champion approach

4.1.1 New automotive investment policy

After the AFC hit and triggered the aforementioned changes in industry regulation, it was necessary to develop a future-oriented strategy to develop the industry. In 2001, Prime Minister Thaksin Shinawatra announced his vision to turn Thailand into 'the Detroit of the East' (Busser, 2008). As Thailand had pledged to deregulate and no longer apply LCR, another approach to strengthen Thai competitiveness was required. It appeared clear that Thailand had to position itself as an export production base as its national market was not large enough to support production with a minimal efficient scale, i.e. to attain a level of production output that enables of economies of scale. As noted earlier, pickup trucks were already popular and there had been past attempts to rationalise diesel engine production (Doner 1991: 202–18). Thus, choosing one-tonne pickup trucks appears to be a path-dependent choice.

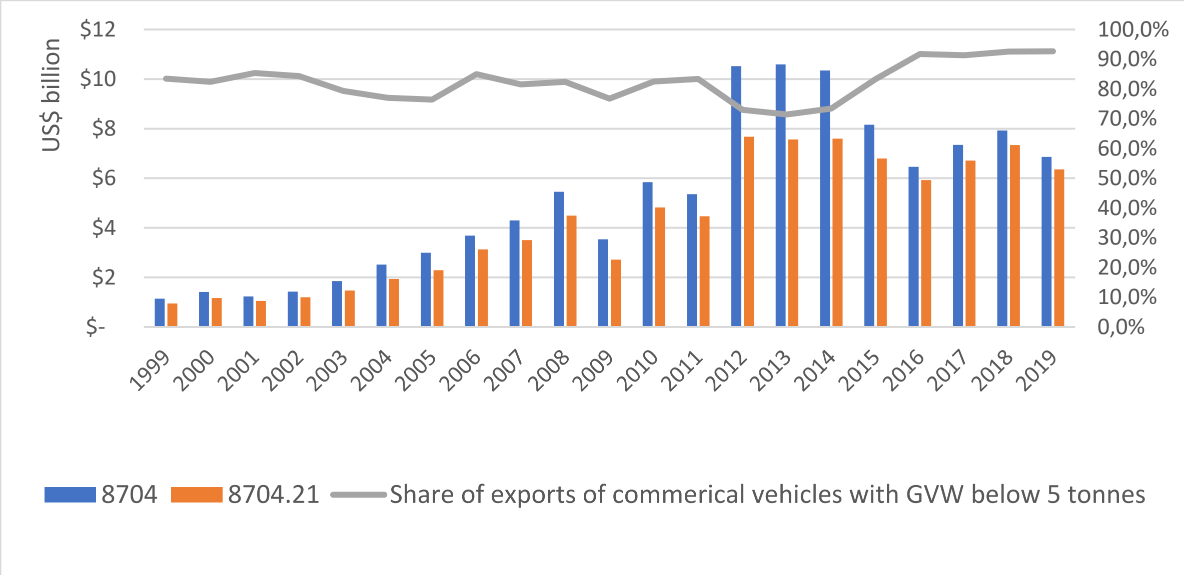
According to Natsuda and Thoburn (2013), this type of targeting should be labelled as the 'product champion approach'. The product champion approach has two noteworthy characteristics. First, both supply and demand side policies are utilised. Despite the fact that policy targets exports, the domestic demand for targeted vehicle types is stimulated in order to avoid being solely dependent on external market development. Second, supply side incentives are clearly structured and tied to performance criteria that not only entail economic targets but also define what particular type of vehicle should be produced. In the case of one-tonne pickup trucks, investors could qualify for corporate tax exemption if they met several investment requirements. The key point of Natsuda and Thoburn is that despite increasing limitations of policy space through the WTO, i.e. the banning of such tools as LCR, export requirements, and trade balance obligations, developing countries still have policy options.

4.1.2 One-tonne pickup truck production

Carmakers responded positively to Thailand's new automotive policy. This cannot be overly surprising as pickups had already been selected by OEMs as export products even before the crisis broke out (Kohpaiboon, 2009: 4). Indeed, Mitsubishi and Auto Alliance, the joint venture plant of Ford and Mazda, had already designated Thailand as an export base for this vehicle type before the crisis, and the partnership between General Motors and Isuzu had applied the same orientation in 2001 (Techakanont, 2011: 209). Toyota designated Thailand as the leading hub for pickup trucks amongst several production hubs for its Innovative International Multi-purpose Vehicle platform, which enabled the production of various models differentiated by body type, i.e. pickup truck, sport utility vehicle (SUV), and minivan (Nomura, 2015: 83-84). Therefore, the post-crisis product champion policy reinforced existing firm strategies rather than shaping them.

Export trade data support these findings, as they display that commercial vehicle exports were almost entirely constituted by light commercial vehicles with a gross vehicle weight (GVW) below five tonnes before Thai policy supported one-tonne pickup trucks (Figure 2).

Figure 2.2: Thai Commercial Vehicle Exports and the Light Commercial Vehicle Share, 1999–2019



GVW = gross vehicle weight.
Source: UN Comtrade; accessed 1June 2020.

Whilst trade statistics are again not disaggregated enough to only capture one-tonne pickup trucks, the fact that the HS subheading they occupy represents more than 90% of total commercial vehicle exports in value terms combined with the aforementioned OEM strategy suggests that pickup trucks are indeed the primary Thai vehicle export. Concerning the export destinations, the ASEAN market is not as important as may be expected. Of all exports in this category, 29.1% were destined for fellow ASEAN markets in 2019. However, the single-most-important export market was Australia with US$2 billion or 32% of all exports in this category in 2019. Other important non-ASEAN export destinations were New Zealand (ranked third; US$470 million), Saudi Arabia (ranked sixth; US$284 million), and the United Kingdom (UK) (ranked seventh; US$270 million).

It is necessary to point out that whilst production in Thailand was primarily focussed on one-tonne pickup trucks, the adoption of a product engineering strategy greatly increased OEM flexibility. Some carmakers located the production of models that were based on platforms[25] in Thailand. Toyota's so-called Innovative International Multi-purpose Vehicle (IMV) platform is perhaps the best example. The IMV platform supported three different models, namely the Fortuner SUV, the Hilux pickup truck, and the Innova minivan. Thailand was the main production location for the Hilux, and further produced completely knocked-down kits of this model for assembly in other developing countries as well as diesel engines for all models of the IMV platform (Agustin and Schröder, 2014: 97-98). Thus, Thailand not only participated in Toyota's intra-regional production network in ASEAN, which increased economies of scale in component and vehicle production, but manufacturing could also be more flexibly adjusted between models using the same platform. Hence, whilst one-tonne pickup trucks

[25] Takayasu and Mori (2004: 222) refer to this as modular strategy. However, from the perspective of product engineering, it appears more appropriate to term this a platform strategy. The main difference between platform and architecture is that whereas platforms have limited scalability and can only support the production of closely related models, e.g. from the same segment, architectures possess greater scalability, especially regarding the wheelbase, and can support production of various models from different segments.

clearly were the most important product, OEMs had the option to adjust production volumes between different, yet related, models.

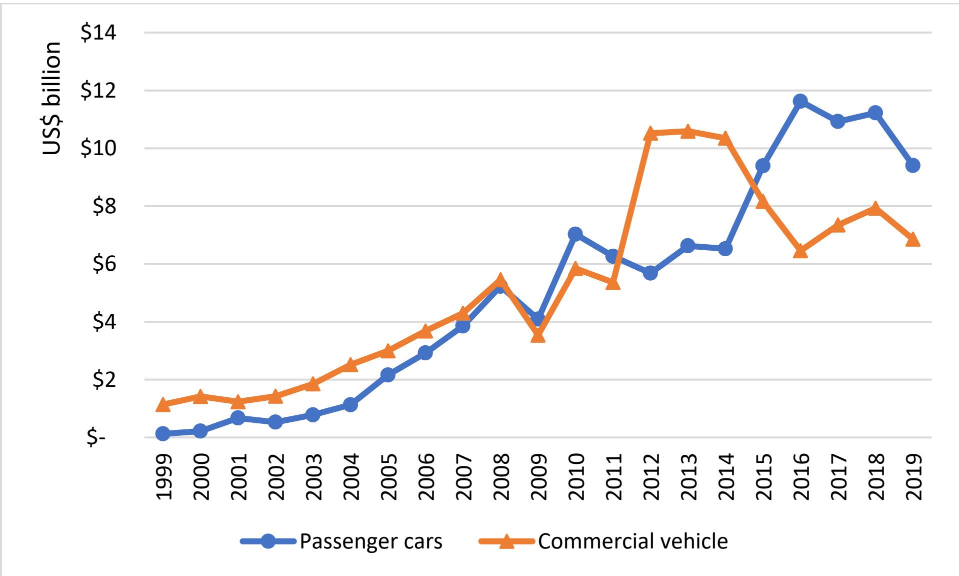
4.2. Eco-cars: Sticking to the recipe

4.2.1 Eco-car programme

Following the success of its first product champion, Thailand has promoted the local production of so-called eco-cars since 2007. The Thai administration defines eco-cars as vehicles that have a mileage above 20 kilometres per litre of gasoline (or diesel equivalent), emit less than 120 grammes of carbon dioxide (CO_2) per kilometre, and meet criteria for other pollutants as required by the Euro 4 standard. Moreover, gasoline engines were limited to a size of 1,300 cylinder capacity (cc) and diesel engines to 1,400 cc in order to require the production of relatively small vehicle types. To further the domestic production of such eco-cars, the Thai Board of Investment (BOI) granted several incentives to both producers and consumers under the condition that investors agree to production target figures of 100,000 units, which had to be reached after a certain period of operation.[26]

Clearly, this policy is designed to promote the evolution of the Thai automotive industry. As past targeting policies led to the specialisation of one-tonne pickup trucks, policy consciously sought to emulate past success. As Thai policymakers, especially the BOI, understood that pickup trucks are both relatively polluting and technologically simple in comparison to eco-cars, this also indicates that the intention was to stimulate industry development towards more complex, higher value-added products. Whilst eco-car promotion clearly aimed at adding another vehicle type to Thailand's exports, exports were already diversifying away from one-tonne pickup trucks at the time the programme was initiated (Figure 3).

Figure 3. Thai Passenger Car and Commercial Vehicle Exports, 1999–2019



Source: UN Comtrade; accessed 1 June 2020.

[26] Due to limitations in space, additional investment conditions and incentive details cannot be discussed.

As the data indicate, vehicle exports had already diversified from being largely constituted by commercial vehicles, especially one-tonne pickup trucks, when the eco-car policy was promoted. Whilst passenger car exports have recently overtaken commercial vehicle exports, it is nevertheless remarkable that passenger car export growth started before the eco-car policy sought to establish a second product champion. Thus, it may be concluded that carmakers were already utilising Thailand as a broader production and export platform before policy promoted diversification. It is, therefore, not sensible to attribute passenger car export growth to sectoral policy alone. Rather, it appears that policy reinforced pre-existing OEM production and export strategies instead of actively shaping them.

4.1.3 Eco-car production

Under the eco-car programme, only Japanese OEMs are still making cars in Thailand. During the first phase of the programme, Honda, Mitsubishi, Nissan, Suzuki, and Toyota established production capacities. Originally, five carmakers joined the second phase of the eco-car programme, namely Ford, General Motors, Mazda, Shanghai Automotive Industry Corporation (SAIC), and Volkswagen. Whilst the German carmaker never set up production in Thailand, all carmakers except Mazda retreated from the programme (Grant, 2015; Reuters, 2015; Maikaew, 2017c).

Whilst the participating carmakers still have time to meet the required production targets, it can be stated that meeting these targets may be challenging for some carmakers.

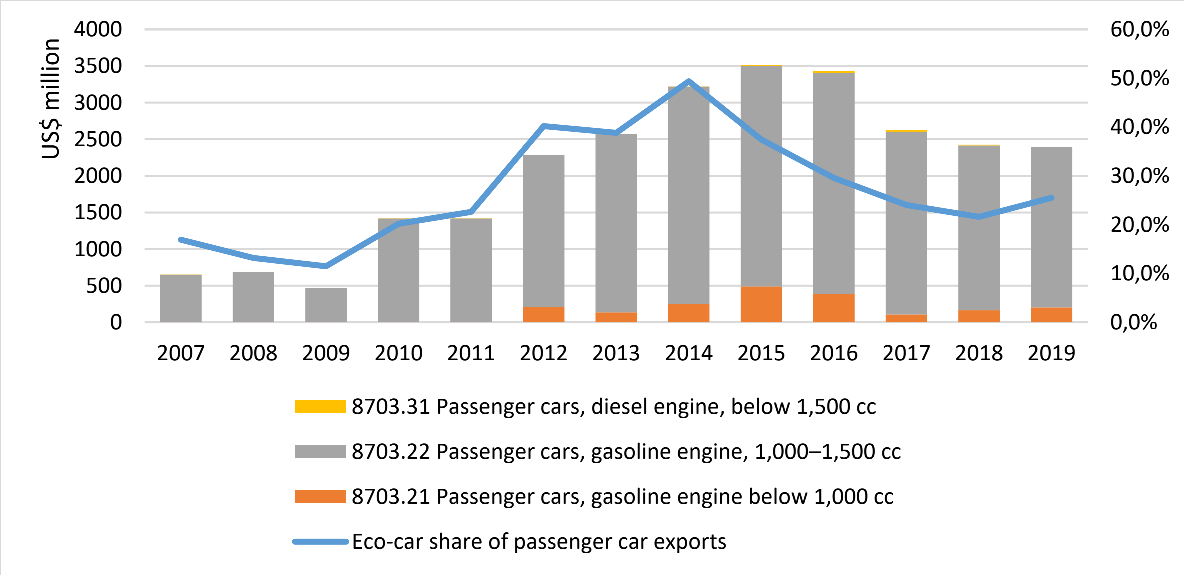
Table 4. Eco-car Domestic Sales and Production

Make	2017	2018
Honda	2,475	2,132
Mazda	31,760	45,972
Mitsubishi	22,833	25,784
Nissan	33,673	42,205
Suzuki	21,300	24,625
Toyota	44,200	68,804
Total sales	**156,239**	**209,522**
Total production	**364,000**	**n.a.**

Note: All brand data are sales, only the final row is production.
Source: Bangkok Post & Federation of Thai Industries.

As the above data indicate, promoting Thailand as an export base was achieved successfully as more than half of the produced eco-cars were exported in 2017. Further, differing sales data suggest that OEMs may adopt different strategies towards mixing production for the Thai market and for export. As Thailand's population is too limited to support its rather large automotive industry, promoting the country's position as an exporter is necessary. Trade data allow a similar conclusion; according to the UN Comtrade database, Thai exports of passenger cars with gasoline and diesel engines below 1,500 cc increased from around US$650 million in 2007, the year the programme started, to US$2.39 billion in 2019 (Figure 4).

Figure 4. Thai Passenger Car Export and Eco-car Export Share, 2007–2019



Source: UN Comtrade; accessed 1 June 2020.

This suggests that carmakers indeed intensified exports of this vehicle class as quasi-required by industrial policy. However, industry trends such as downsized and turbo-charged engines promoted the production and sales of nominally smaller vehicles, so the increased exports should not be solely attributed to the programme. Regarding export destinations, the role of the ASEAN market deserves attention. Whilst all ASEAN markets together were the largest market with US$572 million in 2019, the single-largest export destination was Australia with US$466 million, followed by Viet Nam with US$377 million, Mexico with US$274 million, the US with US$179 million, and Japan with US$118 million. Thus, Thai eco-cars are neither a product solely dedicated to the ASEAN region nor dedicated to other developing or emerging countries. Moreover, eco-cars do not occupy the same role in passenger car exports as one-tonne pickup trucks do in commercial vehicle exports, in that their share of passenger car exports only increased from roughly 17% at the start of the programme to about 25% in 2019. Whilst pickup trucks are the clear product champion when it comes to commercial vehicle exports, eco-cars are just one type amongst others. Whilst one may conclude that the eco-car programme did not succeed in creating a dominant product champion, this is arguably not negative. Instead, it is rather remarkable that passenger car export growth also occurred in vehicle types not specifically supported through policy. This suggests that Thailand is an internationally competitive production and export base that does not necessitate explicit government support for each locally produced vehicle type.

Whilst the retreat of several carmakers may be regarded as a partial failure of the eco-car programme, it can nevertheless be concluded that the programme was relatively successful. First, Thailand diversified the product range of locally made automobiles away from one-tonne pickup trucks towards passenger cars, including not just targeted eco-cars. Whilst the new product champion is characterised by narrow OEM profit margins and is strongly reliant on rather low labour costs, Thailand's ability to attract the production of a cost-sensitive segment suggests that the country is cost-competitive. Second, eco-cars are exported to several markets, suggesting that Thailand is internationally competitive in this segment.

4.3 Electric vehicles: Limitations of the product champion approach?

4.3.1 Electric vehicle programme

Whilst the eco-car programme provided incentives for fuel-efficient ICEVs, Thailand also introduced support measures for EV parts manufacturing in the country. From 2012, it offered exemptions from corporate income tax (with a maximum cap) for eight years for investments directed at the production of advanced vehicle technologies. These included ICEV components as well HEV, plug-in hybrid electric vehicle (PHEV), and battery electric vehicle (BEV) batteries, and traction motors for HEVs, PHEVs, BEVs, and fuel cell electric vehicles. At this time, however, support for EVs can be characterised as a general form of industrial support policy, not a dedicated product champion programme.

This changed in March 2017, when the Thai government issued its EV policy. In comparison with other ASEAN members, the formulated aims are more long-term oriented. The target number for EVs on Thai roads is 1.2 million vehicles by 2036 and 690 charging stations. The available information suggests that the Thai government defines EVs as all types except fuel cell electric vehicles. However, incentives are most generous for BEVs, reflecting a clear preference of government planners for this type.

First, BEV investment projects are entitled to corporate tax exemptions of between five and eight years. The duration of this tax exemption can be extended under the following condition: investment in manufacturing in more than one EV core component in Thailand is rewarded by an additional year per component up to a maximum duration of 10 years.

Second, PHEV and BEV bus investment projects are eligible for corporate income tax exemption for three years and import tariff exemptions on production machinery. As in the case of BEVs, production beyond the first EV core component entitles additional years of tax exemption to a maximum of six years.

Third, investment in HEV manufacturing is entitled to fewer incentives than PHEVs and BEVs. Investing firms will only be granted import tariff exemption on production machinery.

Some striking aspects of the EV programme should be highlighted. First, whilst there is still a minimum investment required, the amount is only B1 million (roughly US$26,000). In comparison to the preceding eco-car programmes, this sum is very low, not to say symbolic. Secondly, differing from eco-car policy, production targets are not included under this scheme. This suggests that policymakers are unable to define a target production figure. Taking these less strict requirements into consideration, it may be concluded that whilst EVs are regarded as important for the future of Thai car manufacturing, the technology is too novel and demand too uncertain to apply standard policy instruments.

Further, incentives will be granted for producing important EV components. Firms investing in manufacturing in the following components are entitled to eight years of corporate income tax exemption: batteries, traction motors, battery management systems, DC/DC converters, inverters, electric circuit breakers, portable EV chargers, and EV smart charging systems. Most remarkable is that battery technology has not been specified clearly. The way the policy is phrased, both major EV battery types, i.e. NiMH and Li-ion batteries, are entitled to government support. Whilst the overall direction of policy measures shows a strong tendency to favour BEVs, it would make sense to give priority to Li-ion batteries, which are commonly used in BEVs and PHEVs, and no or at least lower incentives to NiMH batteries, which are mainly utilised in HEVs.

According to the plan, EV policy is divided into three phases. The first was conducted in 2016 and 2017. It should basically prepare subsequent activities by setting up a limited number of charging stations and organise field tests with a limited number of BEVs. The actual research should be conducted in the second phase, scheduled to last from 2018 to 2020. Trials should test the performance of different battery types and motors and determine the technical standards for vehicles and charging infrastructure. Further, this phase should be utilised to prepare legal and tax frameworks, train bureaucratic staff, and conduct user promotion. The phase should produce a coordinated action plan for the implementation of concrete policy measures from 2021 onwards. Thus, the third stage should see the actual deployment of infrastructure and BEVs in Thailand. Here, it is noteworthy that the EV Action Plan is intended to integrate with other policies, most notably Thailand's Industry 4.0 plans and the smart grid. BEVs should not only be charged through the grid but also be able to feed stored electricity into the grid (so-called vehicle-to-grid capability). Therefore, it can be stated that BEV use and production are part of an intended large-scale transformation of the Thai economy away from a country that faces the 'middle-income trap' towards an industrially and economically advanced nation.

On the demand side, Thailand revised taxation to make EVs more attractive to consumers. In 2016, Thailand introduced a new excise tax scheme that shifted taxation away from being based on engine capacity alone towards one based on CO_2 emissions (Table 5).

Table 5. Thai Automotive Excise Tax Scheme as of January 2018

<table>
<tr><th rowspan="2">Vehicle Type</th><th rowspan="2">Engine Size</th><th colspan="4">CO_2 g/km</th></tr>
<tr><th>< 100</th><th>100–150</th><th>150–200</th><th>> 200</th></tr>
<tr><td rowspan="3">Passenger car</td><td>< 3,000 cc</td><td></td><td>30%</td><td>35%</td><td>40%</td></tr>
<tr><td>E85/CNG</td><td></td><td>25%</td><td>30%</td><td>35%</td></tr>
<tr><td>> 3,000 cc</td><td colspan="4">50%</td></tr>
<tr><td rowspan="2">Hybrid vehicle</td><td>< 3,000 cc</td><td>5%</td><td>20%</td><td>25%</td><td>30%</td></tr>
<tr><td>> 3,000 cc</td><td colspan="4">50%</td></tr>
<tr><td>BEV</td><td>-</td><td>2%*</td><td colspan="3"></td></tr>
<tr><td rowspan="2">Eco-car</td><td>1,300–1,400 cc</td><td>14%</td><td rowspan="2" colspan="3">17%</td></tr>
<tr><td>E85</td><td>12%</td></tr>
<tr><td></td><td></td><td colspan="2">< 200</td><td colspan="2">> 200</td></tr>
<tr><td rowspan="3">Pickup</td><td>Single cab</td><td colspan="2">3%</td><td colspan="2">5%</td></tr>
<tr><td>Space cab</td><td colspan="2">5%</td><td colspan="2">7%</td></tr>
<tr><td>Double cab</td><td colspan="2">12%**</td><td colspan="2">15%</td></tr>
<tr><td rowspan="2">Pickup passenger</td><td>< 3,250 cc</td><td colspan="2">25%</td><td colspan="2">30%</td></tr>
<tr><td>> 3,250 cc</td><td colspan="4">50%</td></tr>
</table>

BEV = battery electric vehicle, cc = cylinder capacity, CNG = compressed natural gas, CO_2 = carbon dioxide, g = gramme, km = kilometre.

* The excise tax will be reduced to zero from 2020 to the end of 2022, after which it will be re-increased to 2%.

** The excise will be reduced to 10% from 2020 to the end of 2022.

Note: E85 signifies a fuel blend of 85% ethanol and 15% gasoline.

Source: Thai Board of Investment.

Whilst the table indicates that CO_2 emissions and engine capacity are actually used in combination to determine the payable taxes, emissions play a more crucial role under the new scheme. Besides this new tax regime, Thailand also reduced import tariffs on BEVs to zero to lower cost for consumers. The measures suggest that Thai policymakers prefer supporting BEVs over hybrids.

4.3.2 Electric vehicle production plans and investment

Due to the recent nature of the programme, it is not possible to review and evaluate this latest policy based on the production data. It is only possible to trace OEM plans through investment decisions and in some cases through commenced production activity.

Looking at current automobile manufacturing in Thailand, Toyota is locally producing the Camry Hybrid (HEV) since 2009 and manufactured the Prius (HEV) from 2010 to 2015. Battery packs used to be imported from Japan, where the carmaker and Panasonic operate three plants under the joint venture named Primearth EV Energy. The Japanese OEM announced that it would intensify HEV production in Thailand to take advantage of the provided incentives. Before the Thai government announced its production incentives, Toyota stated that it regarded charging infrastructure as insufficient, indicating the main reason why it would not invest in PHEV or BEV production (Maikaew, 2017a). Apparently, the incentives did not convince the carmaker to rethink its approach. Under the EV programme, Toyota applied to produce 7,000 HEVs per year plus 70,000 EV batteries as well as other non-EV specific components, such as bumpers, doors, front and rear axles (Maikaew, 2019a). Toyota commenced production of NiMH batteries at its Gateway plant in Chachoengsao Province in May 2019. The produced batteries are currently used in HEV versions of the Camry sedan and the C-HR SUV manufactured at the Gateway plant. Nissan located the manufacture of the X-trail Hybrid (HEV) in 2015, i.e. before government incentives were granted. After incentives were introduced, Nissan applied and pledged to produce hybrids and batteries at its production complex in Samut Prakan Province. In January 2019, it was disclosed that the carmaker seeks to make Thailand its second EV production hub besides Japan, which should produce for local demand and export markets (Maikaew, 2019b). Honda has assembled HEV versions of its Jazz and Accord models since 2012 and 2014, respectively. Between 2013 and 2015, the Civic HEV was also produced, but due to weak sales of the model, the Japanese carmaker discontinued its production worldwide. Under the EV programme, Honda pledged to invest in HEV and HEV battery production. The carmaker plans to shift Accord HEV production from Japan to Thailand (Furukawa, 2019). In 2017, Honda announced that by March 2022, it would shutter its Sayama plant, which represents roughly a quarter of production capacity in Japan. As its plant in Ayutthaya Province also produces the Accord, investment incentives may have only acted as an additional incentive for an already planned reallocation of production within Honda's global production network. After the BOI's EV scheme was introduced, Mazda decided to produce an undisclosed hybrid model and several components in Thailand (Maikaew, 2018). After gaining approval from the BOI, Mazda recently even applied to extend production to BEVs (Maikaew, 2019c).

One example of EV production and partial supply chain localisation is BMW. The premium carmaker started to produce PHEV versions of its 3-series (330e) and X5 models in 2017, i.e. before Thai policy supported local EV production. After the Thai government introduced incentives, BMW extended production to PHEV versions of the 5-series and 7-series (530e and 740Le, respectively) (BMW, 2018). As part of the localisation effort, German supplier Dräxlmaier started to produce Li-ion traction batteries for BMW in Thailand in September 2019. As for the battery, the battery cells are not made locally but imported from Samsung SDI, which has been BMW's exclusive source for EV batteries outside of the Chinese market. Dräxlmaier assembles battery modules and subsequently packs from procured cells and other components, such as aluminium housing and electronic components. The company claims that it is the only plant that produces Li-ion batteries starting from the module stage in Southeast Asia (Maikaew, 2019f). Another German premium rival follows a remarkably similar trajectory. Daimler started to assemble completely knocked-down kits of HEV version of its C-class and E-class (C300 and E300 BlueTEC Hybrid) in 2013 and 2014. In 2016, the carmaker updated its model line-up by starting assembly of PHEV versions of the Mercedes-Benz C-class and S-class (C350e and S500e). After Thailand offered incentives, Daimler decided to deepen its production footprint by applying for PHEV battery production and production of the EQC, a battery-powered SUV (Maikaew, 2019d). Whilst the battery may be produced in Thailand, battery cells will be imported: In the case of the EQC, LG Chem is the sole supplier (The Investor/Korea Herald, 2018).[27] As LG Chem does not produce EV battery cells in Thailand, they will be imported by Daimler. Whether only the cells will be imported or whether they will be already be assembled into modules is unclear at the time of writing. Whilst the two German premium brands produced and offered EVs prior to government incentives, the joint venture between SAIC and local conglomerate Charoen Pokphand (SAIC-CP) pledged to produce PHEV and BEV versions of the MG ZS SUV under the BOI's scheme (Apisitniran, 2018). This is somewhat remarkable as EVs can be imported duty-free from China. Mitsubishi also received approval for its plan to produce an undisclosed PHEV model in Thailand (Theparat, 2019). Given Mitsubishi's production footprint in Thailand, it appears likely that the produced model will be the PHEV version of the Outlander SUV.

Also, there is the case of Vera Automotive, a firm founded by five Thai engineers of King Mongkut's Institute of Technology Ladkrabang (Maikaew, 2017b). The firm developed a BEV called V1, but the vehicle is produced by Geely in China and then exported to Thailand. Thus, whilst the firm is Thai, production is not located in the country, obviously due to the costs related to entering automobile manufacturing. The vehicles are not only sold domestically but also exported to other ASEAN markets and China. First One Mile Mobility (FOMM), a Japanese start-up, entered the Thai market with an investment of roughly US$30 million to build its first factory with annual production capacity for 10,000 units in Chonburi Province (Kotani, 2018). The newcomer will produce its FOMM One minicar, which actually was the first approved project under the EV programme. Finally, Energy Absolute, a Thai corporation mainly active in renewable energy and bio fuel production, successfully applied for BOI support (Maikaew and Praiwan, 2019). The company will produce Li-ion batteries suitable for PHEV and BEV use in a joint venture with the Taiwanese Amita Technologies. The plant will initially have the annual capacity to produce batteries able to store 1 gigawatt hour (GWh) of electrical energy and be expanded to 50 GWh by 2021. Further, it will install a network of 3,000 charging stations under its EA Anywhere brand, and ally with an unidentified vehicle assembler to produce three different EV models – one city car, one multi-purpose vehicle and a sports car – developed in-house.

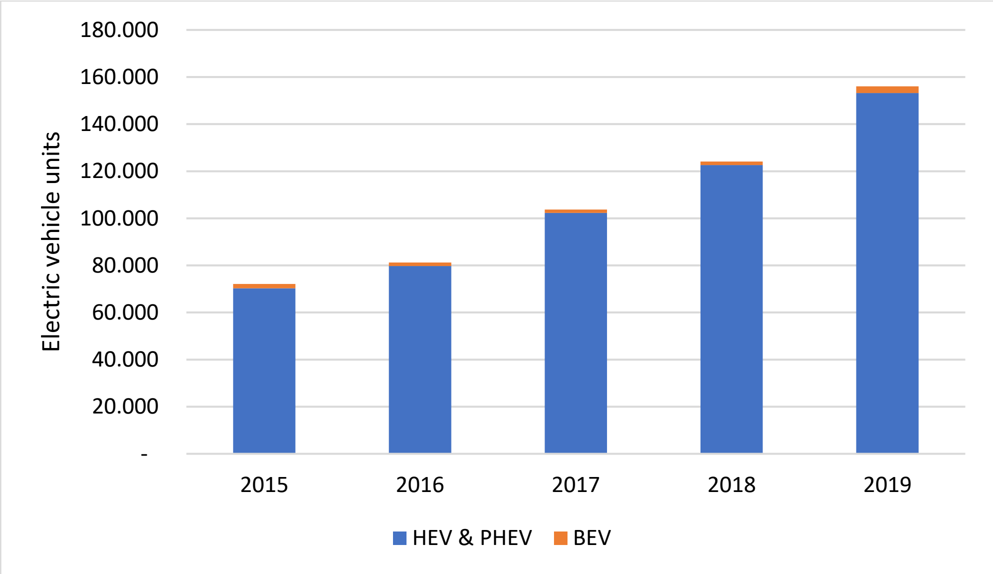
Overall, the EV programme may be called moderately successful. With the notable exceptions of Honda and Nissan, carmakers do not seem to consider Thailand as a significant EV production base. Available data on intended production volumes rather suggest that companies invested to cater to the local market through limited production. It is doubtful that production of this scale will have a significant positive impact on the Thai automotive industry and support a shift towards electromobility. Whilst Honda and Nissan's ambitions may be a ray of hope that Thailand could still be a relevant vehicle production location if the shift to electromobility occurs, the generally lukewarm response from carmakers to the EV programme suggests that the policy may not lead to a transformation of the Thai automotive industry towards EV production.

4.3.3 Local electric vehicle market

[27] At the time of writing, Daimler has supply contracts with three battery cell producers, namely CATL, LG Chem, and SK Innovation.

One reason for carmakers' reserved attitude towards investment in EV production capacities in Thailand is the local market demand. Currently, demand is strongly concentrated on hybrids, and BEVs are a marginal niche market that is mainly constituted of electric motorcycles, not cars (Figure 5 and Table 6).

Figure 5. Accumulated EV Registrations by Type in Thailand



BEV = battery electric vehicles, HEV = hybrid electric vehicles, PHEV = plug-in hybrid electric vehicles.
Source: Electric Vehicle Association of Thailand (2020).

Table 6. Accumulated Battery Electric Vehicle Registrations by Body Type in Thailand as of June 2020

Battery Electric Vehicle Body Type	Registrations
Two-wheeler	2,301
Passenger car	1,731
Bus	120
Three-wheeler	149
Total	**4,301**

Source: Electric Vehicle Association of Thailand (2020).

Overall, the Thai EV market is still a niche market. Whilst annual growth rates are high, they come from a low base. Registrations have increased by roughly 20,000 units annually over the past few years, but given the total market size of about 1 million units sales, EVs are clearly not a mass market. Moreover, data indicate that Thai customers mainly use hybrids instead of BEVs. Further, those few BEVs in use are not cars, but motorcycles. This may explain some carmakers' reluctance towards localising BEV production in Thailand despite more generous incentives for this type in comparison to hybrids. As BEVs are a niche within the Thai EV market niche, this reluctance appears justified, especially if acknowledging that BEVs are still significantly more expansive than conventional ICEVs.

4.4 Eco electric vehicles: Will the product champion approach survive?

At the time of writing, a new programme, dubbed the Eco EV programme, is under deliberation. As it is still under deliberation, concrete measures are unclear, but its aim is identifiable – manufacturers that produce eco-cars should be encouraged to produce electrified versions of these models (Maikaew, 2019e). The reason is quite simple: the EV programme has not resulted in significant EV production capacity but rather promoted the local assembly of a limited number of HEV and PHEV models. Especially in the latter case, vehicles are aimed at market segments beyond the average consumer, meaning that electromobility will not be significantly promoted. The aim of the Eco EV programme is to locally produce EVs that can be both consumed by average Thais and exported in larger numbers.

Therefore, it can be stated that the programme is designed to address the shortcomings of the EV programme. In particular, the lack of clear requirements, such as minimum production targets, seems to have caught the attention of policymakers. As the absence of requirements have allowed carmakers to apply for incentives without building a substantial EV production capacity or supply chain, this policy apparently should provide better-defined requirements.

Carmakers have openly communicated their displeasure with the proposed rules, stating that the required technology was not appropriate to be used.

5. Discussion and Policy Implications

Against the background of Natsuda and Thoburn's argument for the product champion approach, some fundamental observations are noteworthy. First, policy tools banned by the WTO can still be applied if repackaged into conditional investment incentives. Basically, the requirements to qualify for incentives are variants of the LCR and export requirements. As observed, the required production targets exceed the local market capacity, indirectly forcing OEMs to export from Thailand. In essence, this means that whilst certain policy tools can no longer be unilaterally applied by developing countries, they can be repacked as conditions for fiscal incentives. Thus, it may be stated that formerly unilaterally applied policy tools were transformed into mutual agreements, i.e. incentives are only provided if firms support industrial development goals. Second, policy tools are still usable but require fiscal muscle. Whilst upper-middle-income countries such as Thailand may realistically adopt such repackaged policy tools, lower-middle-income and low-income countries will commonly lack sufficient government expenditure to pursue incentive-based tit-for-tat development strategies.

Applying past policy blueprints, Thailand seeks to transition domestic vehicle and automotive component production towards the anticipated age of electromobility. Whilst the programme has not been completed, only limited conclusions can be drawn. Most carmakers that applied under the EV programme aim to produce a limited amount of EVs in Thailand, suggesting that OEMs take advantage of incentives to produce EVs locally for a niche market. BMW and Daimler are probably the best examples, as their target customers are already in a fairly narrow segment of the overall market. Honda and Nissan are the only carmakers that plan to establish more substantial EV production in Thailand. However, Honda's intention to produce HEVs indicates that the carmaker anticipates a gradual transition, i.e. a rather evolutionary than revolutionary change in vehicle production. It must be stressed that the degree of change inside Thailand's automotive industry may be linked to Honda and Nissan's future EV production volume. If both Japanese OEMs are successful in establishing Thailand as their EV production and export hub, competitors may emulate their strategy.

Regarding the implications for Thailand's automotive sector policy, it must first be pointed out that there is a significant underlying issue with the product champion approach. Basically, this policy approach practices targeting in that it attempts to single out a vehicle type or segment in order to promote large-scale production in Thailand for global export. Arguably, this is possible as long as the automotive industry is subject to incremental innovation and development because policymakers only have to be able to identify a vehicle type that should be fairly attractive for a large number of consumers around the globe. However, EVs, and especially BEVs, which are the obvious target of Thai policymakers, do not fit into this pattern easily. As outlined, there are several EV types with specific costs, environmental performance, and infrastructure requirements, etc. Furthermore, different markets display differing preferences for different EV types, often rooted in government policies and consumer subsidies. Hence, targeting EVs is significantly more challenging than ICEVs. Specifically, requiring production at a level that quasi-mandates export is not possible as OEMs will not commit to large-scale EV production without being able to forecast demand with an acceptable margin of error. Therefore, the product champion strategy may be well-suited for catching-up in a stable automotive industry environment, but it appears inappropriate for promoting innovative EV types with uncertain demand.

Challenges to targeting innovative vehicle types such as EVs apparently have consequences for policy design (Table 7).

Table 7. Overview of Thai Post-crisis Automotive Industry Policies

		New Automotive Investment Policy	**Eco-car**		**Electric Vehicle**
			Phase I	**Phase II**	
Year		2002	2007	2013	2017
Minimum investment		B10 billion	B5 billion	B6.5 billion (B5 billion for Phase I participants)	B1 million
Export requirement (% of production)		80	-	-	-
Annual production		-	100,000 units in the fifth year	100,000 units in the fourth year	-
Mileage		-	20 km/L	23 km/L	-
Emission standard		Euro 2*	Euro 4	Euro 5	-
CO_2 emissions		-	120 g/km	100 g/km	-
Engine displacement	Gasoline engine		≤ 1,300 cc		
	Diesel engine		≤1,400 cc		
Incentive		3–7-year income tax exemption; 1-year extension requires Thai supplier development or local R&D; import tax	8-year income tax exemption	6-year income tax exemption; 1- or 2-year extension requires Thai supplier development	Income tax exemption (BEV: 8–10 years; PHEV and BEV buses: 3–6 years); import tax exemption for production

	reduction for production machinery			machinery (BEV, PHEV, HEV)

BEV = battery electric vehicle, cc = cylinder capacity, CO_2 = carbon dioxide, g = gramme, HEV = hybrid electric vehicle, l = litre, R&D = research and development, PHEV = plug-in hybrid electric vehicle.
* There was no formal requirement. However, the local adoption of the Euro 2 emission standard plus the export requirement can be regarded as making the adoption quasi-mandatory.
Source: author's investigation.

Whereas the earlier product champions required a relatively high investment and output targets to qualify for subsidies, the latest iteration of the EV programme lacks such clear requirements and evaluation criteria. What may be described as a balance between incentives and investment requirements in the past has degenerated into subsidisation that does not require significant investor performance. Arguably, the inability to establish performance criteria is due to the uncertain nature of the targeted technology. It follows that whilst the product champion approach has its merits if technology is developing rather incrementally, it is not suitable to target technologies that are more radical and unpredictable in nature. If Thai policymakers intend to continue targeting specific product champions, it appears advisable to focus on ICEV segments for which global demand may be forecasted more reliably.

In more general terms, this suggests that Thailand should shift away from traditional industrial policy instruments such as the product champion approach towards a more encompassing innovation policy. Simultaneously, it is noteworthy that the EV programme is embedded into a broader EV plan that seeks to create linkages with other sectors, such as smart electricity grids, i.e. there are signs that Thai policy is already shifting towards innovation policy. As outlined above, however, established policy tools may have to reconfigured or even abandoned for this shift.

Concerning EV component production, it appears advisable to reconsider support for EV battery production. As value-added is low if only pack or module production is conducted, providing incentives corresponding to the particular stage of battery manufacturing performed in Thailand seems reasonable. Creating different echelons of support could encourage firms to perform more production steps inside Thailand, allowing the country to capture higher value-added. In this way, Thailand may not overpay investors that only locate pack assembly. Regarding the preceding refining and processing stages of the EV Li-ion value chain, it appears unlikely that Thailand will be able to attract production. This is not due to deficient policy but rather due to a very narrow specialisation in these processes by a few Northeast Asian firms. Even advanced economies, such as France, Germany, and the US, do not play any significant role in this part of the global supply chain, i.e. production in these countries also only starts at the cell stage at the earliest.

Secondly, regarding the product champion approach, its potency must be scrutinised more critically. Whilst the term appears appropriate for pickup trucks, which dominate both domestic sales and commercial vehicle export, the term appears questionable for eco-cars. As discussed, eco-cars have never constituted a dominant share of Thai passenger car exports. Whilst passenger car export growth has accelerated after the eco-car programme was implemented, exports of larger passenger cars grew more strongly than eco-cars. Whilst this suggests that the product champion policy failed, this may not necessarily be true.

Considering the question of why export growth occurred mainly in the above segments targeted by the eco-car programme, the cases of Mazda and Toyota may hint at an explanation. Whilst the Mazda

2 model is part of the programme, only its gasoline version meets the programme criteria. Whilst the gasoline engine with 1.3 L engine displacement does not exceed the engine capacity requirement, the diesel engine (1.5 L) falls outside this requirement. Regarding Toyota, the model that qualifies under the programme is the Yaris (1.2 L gasoline), which has been produced since 2013 at the Gateway plant in Chachoengsao province. In the same year, Toyota also started to produce the Vios (1.5 L gasoline; 1.5 L flex fuel since 2016) at the same location. Both vehicles are based on Toyota's B platform. Both examples suggest that carmakers have developed increasingly encompassing product platforms or architectures that allow them to simultaneously meet politically defined production requirements and retain manufacturing flexibility to produce vehicles that fall outside targeted parameters. Thus, the export growth of non-targeted segments may be attributed to the utilisation of production capacity for vehicles outside the policy target. The capability to produce a mix of politically supported and other vehicles is beneficial to carmakers in case targeted vehicle types prove unsuccessful in the market. Concerning the product champion approach, it may have been successful at attracting manufacturing investment to Thailand, but the increasing scalability of product platforms (or better architectures) allows carmakers to comply with policy requirements and simultaneously retain options to shift production away from targeted vehicle types if the market shifts towards non-targeted types. It follows that evaluating the success (or lack thereof) becomes increasingly complicated due to more adaptable design and production. Policy may accidentally have targeted vehicle types that fall within the scope of a sufficiently adaptable platform, and OEMs decided that untargeted types of these platforms had higher export potential than targeted eco-cars alone.

6. Conclusion

Thailand's position in EV and related parts production was investigated against the background of industrial policy and global supply chains. For the former, Thailand is not currently a significant producer of EVs or EV-grade batteries but may have the potential to participate in the production of other components, such as electric motors, converters, and inverters. Further, at least two Japanese carmakers plan to make Thailand their secondary EV production hubs after their home country, suggesting that Thailand may successfully transform itself from a producer of conventional vehicles to one of electric alternatives.

Regarding policy, past Thai targeting appears to have been relatively successful. However, the case of eco-cars indicates that despite targeting smaller passenger cars, export growth did also occur in other passenger car segments. Thus, it may be questioned whether policy achieved its objectives even in cases that appear superficially successful.

Finally, the product champion approach of targeting a particular vehicle type for production and export clearly reaches its limitations when it is employed to target more innovative technology, such as EVs. Thus, whilst this policy tool can be successfully used within favourable framework conditions, it may be inappropriate when the context changes. Therefore, adapting policy tools towards changed framework conditions, or in this case shifting from industrial towards more encompassing innovation policy, seems to be advisable.

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Appendix: Electric Vehicle Lithium-Ion Battery Supply Chain Locations

Product	Component	Part	Company	Country of Origin	Production Location(s)
Pack			AESC	China	Jiangsu (China); Kanagawa (Japan); Tyne and Wear (United Kingdom (UK)); Tennessee (United States (US))
			BYD	China	Guangdong (2x), Qinghai, Under construction: Chongqing (all: China)
			CATL	China	Guangdong, Jiangsu, Qinghai (China); Under construction: Thuringia (Germany)
			Dräxlmaier	Germany	Baden-Württemberg & Bavaria (Germany); Chonburi (Thailand)
			Energy Absolute	Thailand	Under construction: Chachoengsao (Thailand)
			GS Yuasa	Japan	Kyoto (2x) (Japan); Borsod-Abaúj-Zemplén (Hungary)
			LG Chem	Republic of Korea	Chungcheongbuk (Republic of Korea); Jiangsu (China); Lower Silesia (Poland); Michigan (US)
			Northvolt	Sweden	Västerbotten (Sweden)
			Panasonic	Japan	Hyogo (3x) (Japan); Liaoning (China); Nevada (US)
			Samsung SDI	Republic of Korea	Styria (Austria); Jilin (China); Pest (Hungary); Michigan (US)
			SK Innovation	Republic of Korea	Chungcheongnam (Republic of Korea); under construction: Jiangsu (China); Komárom-Esztergom (Hungary); Georgia (US)
	Battery management system (BMS)		Calsonic Kansei	Japan	
			Denso	Japan	
			Dräxlmaier	Germany	
			Hyundai Kefico	Republic of Korea	
			Mitsubishi Electric	Japan	
	BMS semiconductor		Fujitsu Semiconductor	Japan	
			Infineon	Germany	
			NXP	Netherlands	
			Renesas	Japan	
			Texas Instruments	US	
Cell			AESC	China	Tyne and Wear (UK); Tennessee (US)
			BYD	China	Guangdong (2x), Qinghai, Under construction: Chongqing (all: China)

			CATL	China	Guangdong, Jiangsu, Qinghai (China); Under construction: Thuringia (Germany)
			GS Yuasa	Japan	Kyoto (2x) (Japan)
			LG Chem	Republic of Korea	Chungcheongbuk (Republic of Korea); Jiangsu (China); Lower Silesia (Poland)
			Northvolt	Sweden	Västerbotten (Sweden)
			Panasonic	Japan	Hyogo (3x) (Japan); Liaoning (China); Nevada (US)
			Samsung SDI	Republic of Korea	Ulsan (Republic of Korea); Shaanxi (China); Pest (Hungary)
			SK Innovation	Republic of Korea	Chungcheongnam (Republic of Korea); Under construction: Komárom-Esztergom (Hungary); Georgia (US)
	Cathode	Aluminium foil	UACJ Foil	Japan	
		Active materials	Nichia	Japan	Tokushima (Japan)
			Toda Kogyo	Japan	Yamaguchi, Fukuoka (Japan); Michigan, Ohio (US)
			Umicore	Belgium	Guangdong (China); Chungcheongnam (Republic of Korea); Under construction: Opole (Poland)
	Anode	Cooper foil	Furukawa Electric	Japan	Tochigi (Japan)
			Nippon Denkai	Japan	Ibaraki (Japan)
			UACJ Foil	Japan	Shiga (Japan)
		Active materials	BTR Energy	China	Heilongjiang, Shaanxi; Under construction: Guangdong) (all: China)
			Hitachi Chemicals	Japan	Ibaraki (Japan)
			Nippon Carbon	Japan	Toyama (Japan)
			ShanShan Tech	China	Hunan, Shanghai, Zhejiang (2x) (all: China)
	Electrolyte		CapChem	China	Jiangsu (China); Lower Silesia (Poland)
			Panex-Etec	Republic of Korea	Chungcheongnam (Republic of Korea); Johor (Malaysia)
			Mitsui Chemicals	Japan	Aichi (Japan); Zhejiang (China)
			Ube	Japan	Osaka (Japan); Jiangsu (China); Michigan (US)
			Zhangjiagang Guotai-Huarong	China	Jiangsu (China); Lower Silesia (Poland)
	Separator		Asahi Kasei	Japan	Miyazaki, Shiga (Japan); Shanghai (China), Chungcheongbuk (Republic of Korea); North Carolina (US)
			SK Innovation	Republic of Korea	Chungcheongbuk (Republic of Korea); Under construction: Jiangsu (China); Silesia (Poland)

		Teijin	Japan	Chungcheongnam (Republic of Korea)
		Toray	Japan	Tochigi (Japan); Chungcheongbuk, Gyeongsanbuk (Republic of Korea)

Source: Author's investigation.