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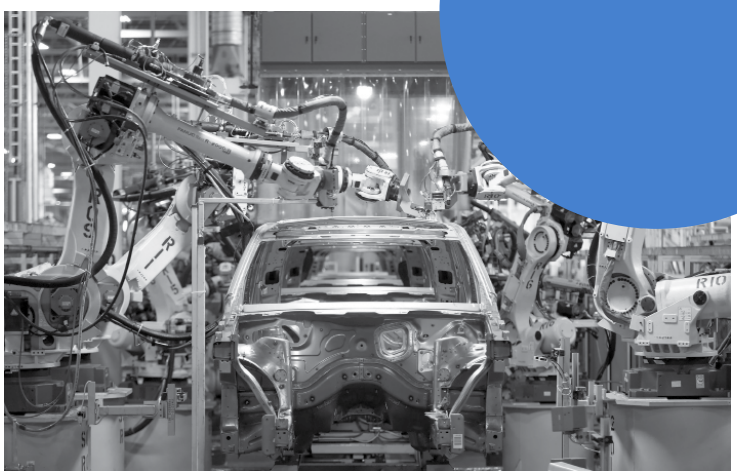

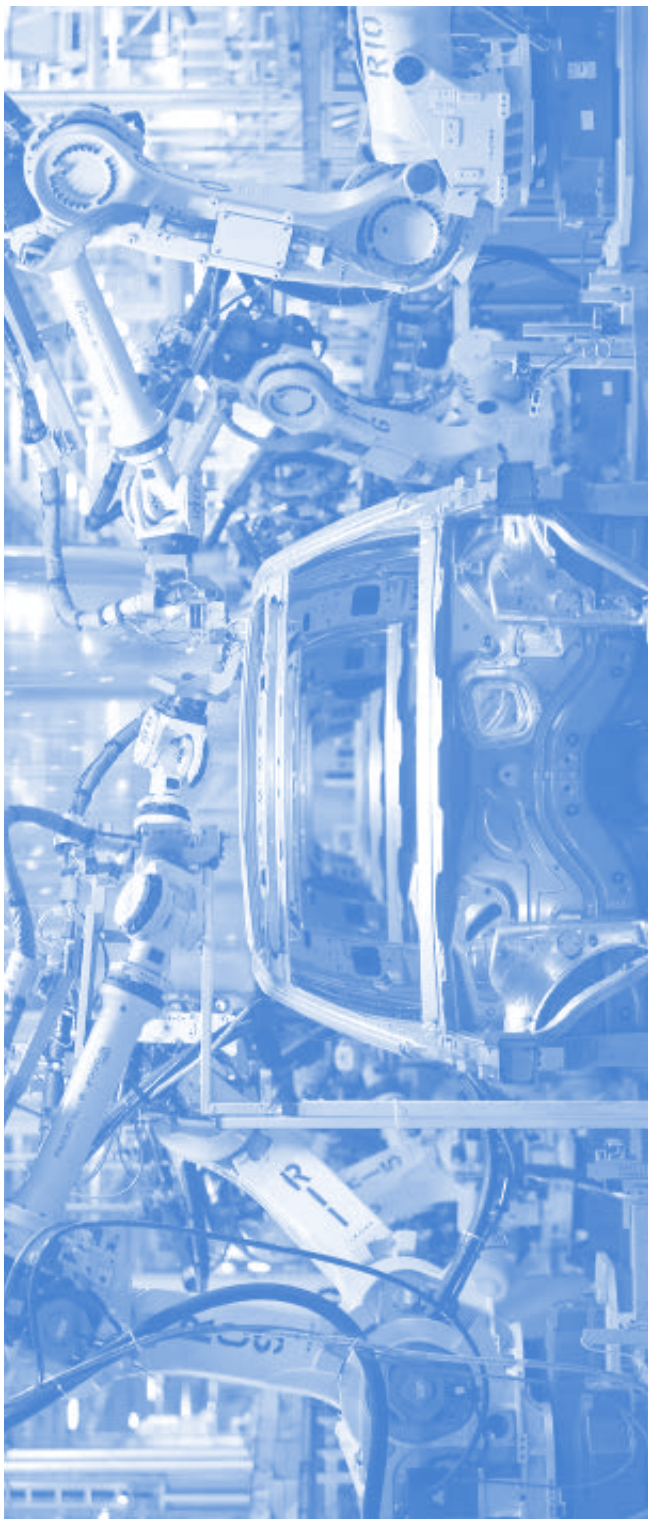

THE FUTURE OF THAILAND'S AUTOMOTIVE INDUSTRY: POLICY CONSIDERATIONS

Panuwat Tajai
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1. INTRODUCTION

In recent years, the landscape of the global automobile industry has undergone a major transition shaped by two megatrends. First, fueled by the global need to mitigate the adverse impacts of climate change and the energy security crisis, many countries are demanding the production of a more energy-efficient and environmentally friendly automobile fleet. Second, technological advancement and modern lifestyles will make connectivity and information technology (IT) the "must-have" functions in cars of the future.

The first trend, the global need for "greener" automobile fleets, manifests itself through the tighter corporate average fuel efficiency (CAFE) standard that many countries have adopted. The CAFE standard stipulates that each automobile manufacturer must produce vehicles that have a weighted average fuel efficiency that is under a specified national standard. Figure 1 displays the past, current, and planned CAFE standards in major automobile markets. There is a clear trend toward much more fuel-efficient automobile fleets in the next 5-10 years.

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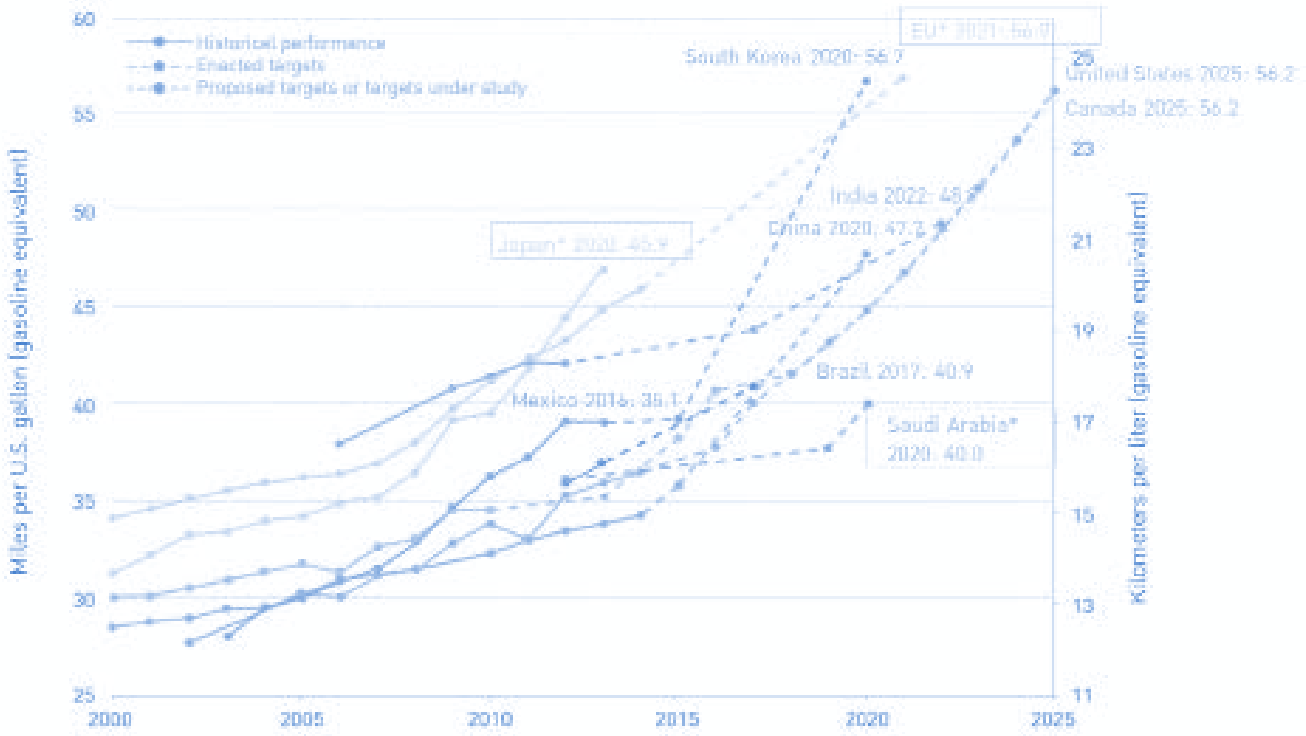
Figure 1: Evolution of the corporate average fuel efficiency (CAFE) standards in major markets



Source: International Council on Clean Transportation.
Note: Boxes indicate Thailand's major export markets.

It has become evident that many conventional automobile producers are struggling to adjust their production of vehicles in response to rising expectations. Recent scandals involving intentional manipulation of fuel efficiency and emission rates of certain types of engines by leading German and Japanese automakers indicate that the conventional fossil-fuel internal combustion engine might have reached its technological frontier. This situation has opened up a window of opportunity for greener technologies, especially electric-powered engines, which range from hybrid engines to pure electric engines.

The second trend, the demand for "smarter" and more connected automobiles, is propelled by technology-enabled changes in consumers' lifestyles. The automotive software and sensors with which vehicles are equipped have advanced to a stage where they can assist the driver in terms of safety and comfort on the road. Moreover, autonomous driving is a foreseeable major step that will reshape the way people commute. Future generations of vehicles will be developed to be connected, think, or even self-drive.

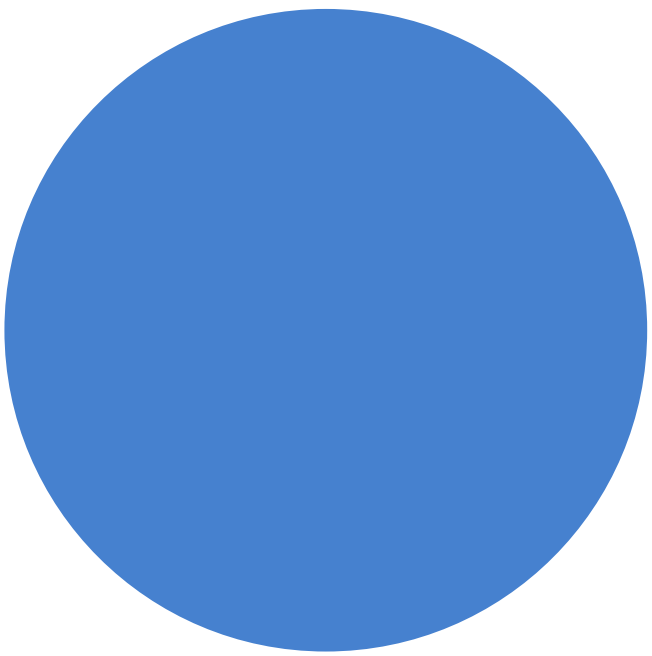
Lacking specialties in IT and artificial intelligence (AI), many existing automobile manufacturers have striven to form partnerships with software and sensor companies in response to the second megatrend. Connectivity features in next-generation automobiles also give rise to a new business model, for example the ride-sharing business. The recent partnerships between automakers, software and sensor developers, and ride-sharing providers can be seen in Figure 2.

Figure 2: Partnership between car/auto parts makers, software and sensor developers, and ride-sharing providers

Partnership	Year
Continental – Google	2013
BMW - Baidu	2014
Volvo - Microsoft	2015
Bosch - Tomtom	2015
Bosch – Google	2015
Volkvagen - GM - Mobileye	2016
BMW - Intel - Mobileye	2016
Toyota - Microsoft	2016
Ford - Pivotal	2016
Delphi - Mobileye	2016
Renault-Nissan - Sylpheo	2016
Volvo – Autoliv	2016
Delphi - Quanergy	2016
Hyundai - Google	In discussions

Partnership	Year
BMW - Scoop Technologie	2016
Toyota - Uber	2016
Volkswagen - Gett	2016
GM - Lyft	2016
Volvo – Uber	2016

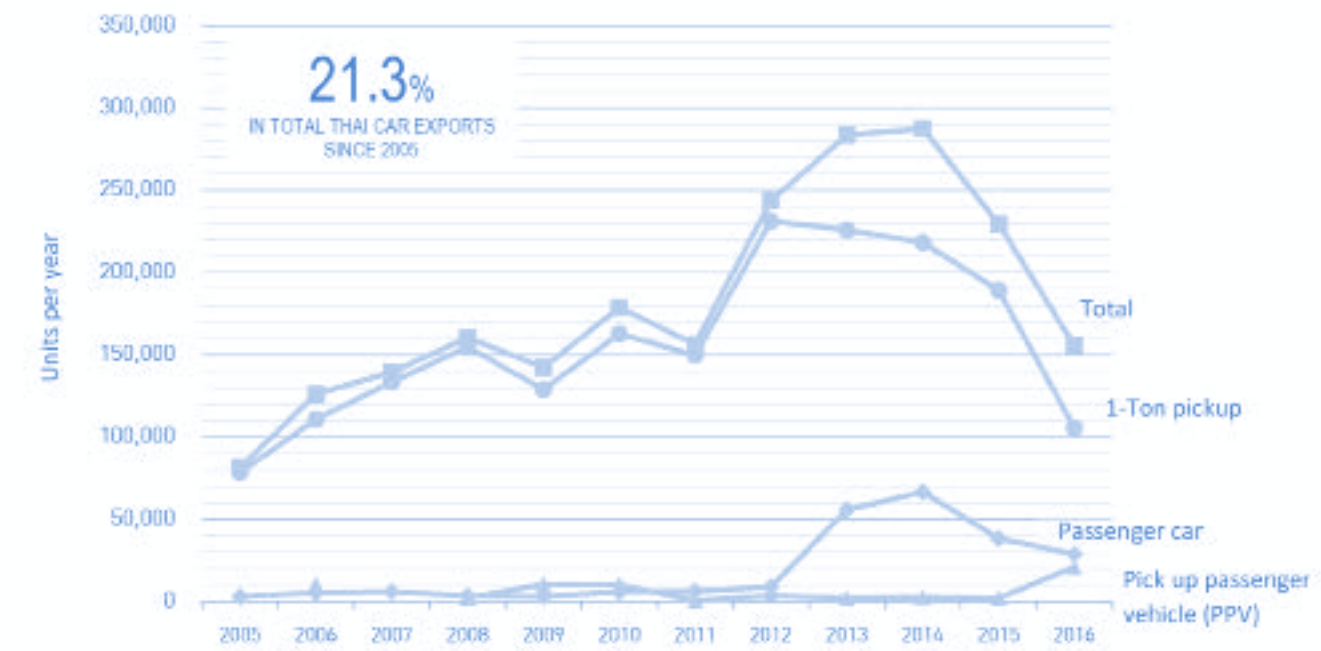
Source: Authors' compilation from various sources.



Amid the changes driven by the two megatrends, newcomers have successfully penetrated into various positions in the automotive value chain. Promising examples are the electric car assemblers Tesla Motors and BYD, battery makers, such as Panasonic and LG Chem, and automotive IT developers, such as Google, Microsoft and Baidu. In short, the most value-added parts for the next generation of mobility are no longer made in Detroit, but in Silicon Valley, China, and even Israel.

Once dubbed the "Detroit of Asia," Thailand has every reason to be alarmed by these major transitions. The disruptive forces threatening the global auto industry have already been sensed in the country. For instance, the Thai automobile industry suffered a decline in top export products (automobiles and auto parts) in early 2016 (Figure 3). The decline is partly due to the tightening CAFE standard in key markets, especially in the Middle East, which accounts for 21.3 percent of Thailand's total car export between 2005 and 2016.

Figure 3: Thailand's car exports to the Middle East



Source: Thailand Automotive Institute.

Figure 4: Next-generation automotive technology

Source: Authors' definitions.

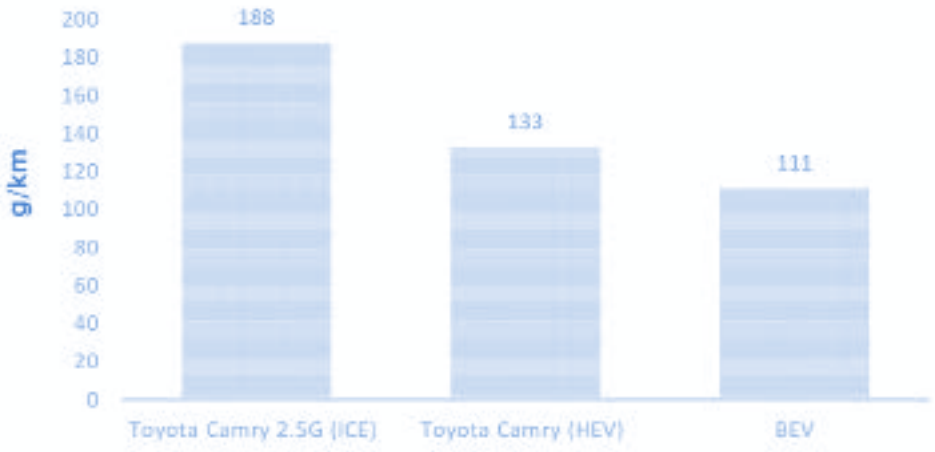
2. NEXT-GENERATION AUTOMOBILES

Next-generation automobile technologies include not only battery-powered electric cars, but also a wide range of new technologies ranging from fuel-efficient ICEs (internal combustion engines), HEVs (hybrid electric vehicles), PHEVs (plug-in hybrid electric vehicles), BEVs (battery-powered electric vehicles), and FCEVs (fuel-cell electric vehicles), as shown in Figure 4.

Even though fuel-efficient ICE vehicles may still exist for the next several decades, it is apparent that electric engines are taking over ICEs as the dominant driving technology. This is because electric engines possess several advantages over ICEs, as shown below:

- Electric engines are more fuel-efficient: Electric engines are more fuel-efficient than ICEs. According to the United States Environmental Protection Agency, all-electric

Figure 5: Carbon dioxide emissions per km in vehicles powered by ICEs, HEVs, and BEVs



Source: Authors' calculations.
Note: Carbon dioxide emissions per km driven take into account tailpipe emissions (for ICE and HEV), as well as emissions for electricity generation (for BEV).

vehicles "convert about 59%-62% of the electrical energy from the grid to power at the wheels. Conventional gasoline vehicles only convert about 17%-21% of the energy stored in gasoline to power at the wheels."[1]

- Electric engines need less maintenance: Electric engines consist of many fewer moving parts than ICEs, which are composed of more than 2,000 moving parts. Fewer parts mean less likelihood of malfunctioning that would require maintenance.

- Electric engines alleviate the problem of energy security: Electricity can be produced from various sources, including domestic fuel, especially biomass and other renewables, which makes electricity less susceptible to price fluctuations and supply disruptions compared with gasoline.

- Electric engines are more environmentally friendly: Since electricity can be produced from renewable resources, electric vehicles have a much smaller environmental footprint compared with ICEs that use gasoline. Figure 5 shows the average carbon dioxide emissions per km in vehicles powered by ICEs, as well as HEVs, and BEVs (of the comparable models).

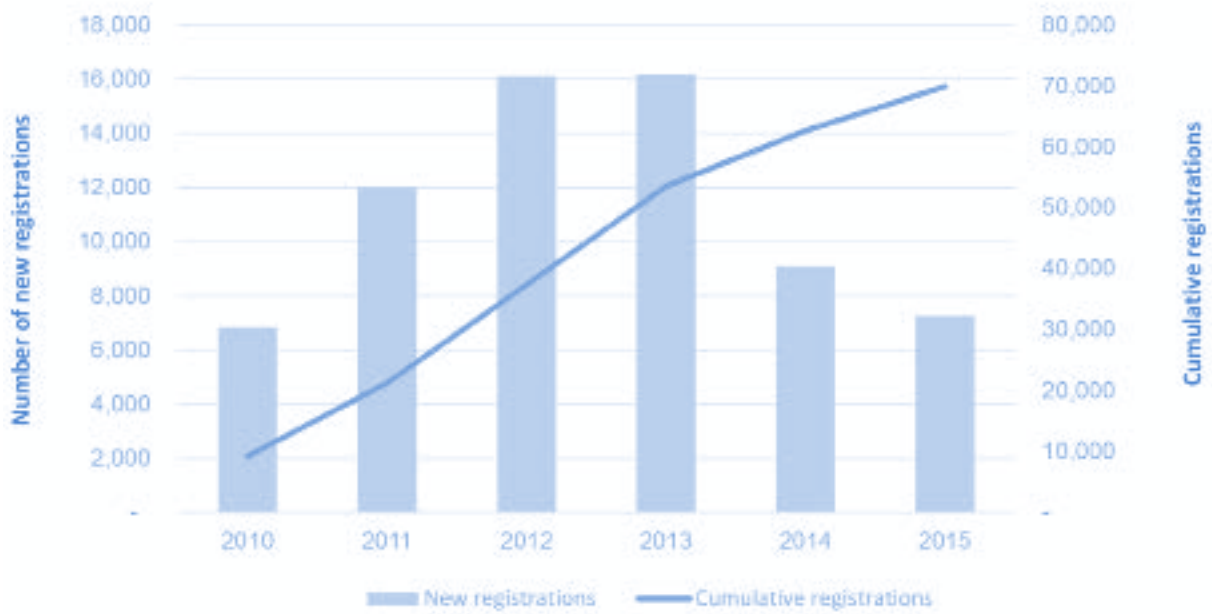
3. CURRENT MARKET SITUATION OF THE NEXT-GENERATION AUTOMOBILES IN THAILAND

Despite the advantages mentioned previously, the market for electric-engine automobiles (HEV, PHEV, BEV, FCEV) is still in its infancy in Thailand.

One of the major obstacles that limits market expansion is the price premium that electric-engine vehicles face over that of most of the popular ICEs. There are two main reasons for this cost disadvantage. First, the majority of electric-engine vehicles have to be imported into Thailand, which adds extra tariff costs to that of the vehicles' base price. Second, the current automobile excise tax structure does not entirely favor environmentally friendly vehicles. These points are elaborated in the following subsections.

[1] *https://www.fueleconomy.gov/feg/evtech.shtml#end-notes.*

Figure 6: New and cumulative HEV registrations, 2010-2015



Source: Department of Land Transport, New Passenger Vehicle Registration.

Potential Impact of Import Tariffs on Domestic Demand

Figures 6 and 7 demonstrate the potential impact of import tariffs on HEV demand. Hybrid electric vehicles (HEVs) were introduced into Thailand in 2007; however, as of 2015, HEVs constituted only a small fraction of all new automobile purchases (less than 2% of the new annual registrations).

Figure 6 indicates that the number of new HEV registrations spiked in 2011 and 2013. The increase in sales was the result of a temporary tariff exemption for important parts, mostly electric drivetrain components, for HEVs that were assembled in Thailand from 2010 to 2013.[2] The tariff exemption effectively reduced the sales price of HEVs by about 20,000 baht per vehicle.[3] After this preferential measure expired, however, the tariffs rebounded to the normal rate, with the maximum rebound rate being 60 percent for certain components.

This observation suggests that a price reduction (through tariff exemption, adjustment of excise tax, or the grant of a purchase tax credit) could be an effective way to expand the domestic market for electric vehicles. Yet, to confirm this relationship, further study on the price elasticity of automobile demand is needed.

Current Automobile Excise Tax does not Favor Environmentally Friendly Vehicles

Even though the most recent excise tax structure enacted in early 2016 is claimed to be based on carbon dioxide emissions, our study shows that this is not entirely so. Instead, the current excise tax structure tends to favor one-ton pickups and eco-cars, which are Thai product champions. HEVs, PHEVs, and BEVs, despite the fact that they emit less carbon dioxide than many ICE vehicles, do not necessarily require the payment of lower excise tax.

Figure 8 shows the relationship between the total excise tax payment and the carbon

[2] *See the Royal Thai Government Gazette database [http://www.ratchakitcha.soc.go.th/DATA/PDF/2553/E/121/18.PDF].*

[3] *http://www.manager.co.th/iBizChannel/ViewNews.aspx?NewsID=9530000089606.*

Figure 7: HEVs' share of all new registrations, 2010-2015

Source: Department of Land Transport, New Passenger Vehicle Registration.

dioxide emissions rate for each vehicle model as contained in the Eco-sticker database.[4] Each marker represents all the vehicle models of the same type that have the same carbon dioxide emission rate (in g/km).

If the excise tax is based entirely on the amount of lifetime carbon dioxide emissions, vehicles that emit the same level of carbon dioxide should pay the same amount of tax regardless of the vehicle type. For example, a hybrid car that emits carbon dioxide at a rate of 100 g/km should pay the same amount of tax as an eco-car that emits carbon dioxide at a rate of 100 g/km. Figure 8 demonstrates that this is not necessarily the case. In other words, for the same level of carbon dioxide emissions, eco-cars and pickups require payment of significantly lower excise taxes than other types of vehicles. HEVs and PHEVs, which emit less carbon dioxide than most vehicles in the market, pay much higher excise tax than eco-cars, ICE E85s, and certain traditional ICEs.

Moreover, Figure 8 shows that as the carbon dioxide emissions rate increases, the excise taxes on eco-cars and pickups increase at a much slower rate than other types of vehicles. The shaded ovals depict the rate at which the excise taxes increase in line with carbon dioxide emissions for each type of vehicle. The steeper the oval, the faster the excise tax increases as carbon dioxide emissions increase. In this figure, it is clear that the eco-cars and pickups have the least steep ovals, meaning that their excise taxes do not increase much as carbon dioxide emissions increase. HEVs and PHEVs, on the other hand, do not enjoy equal treatment.

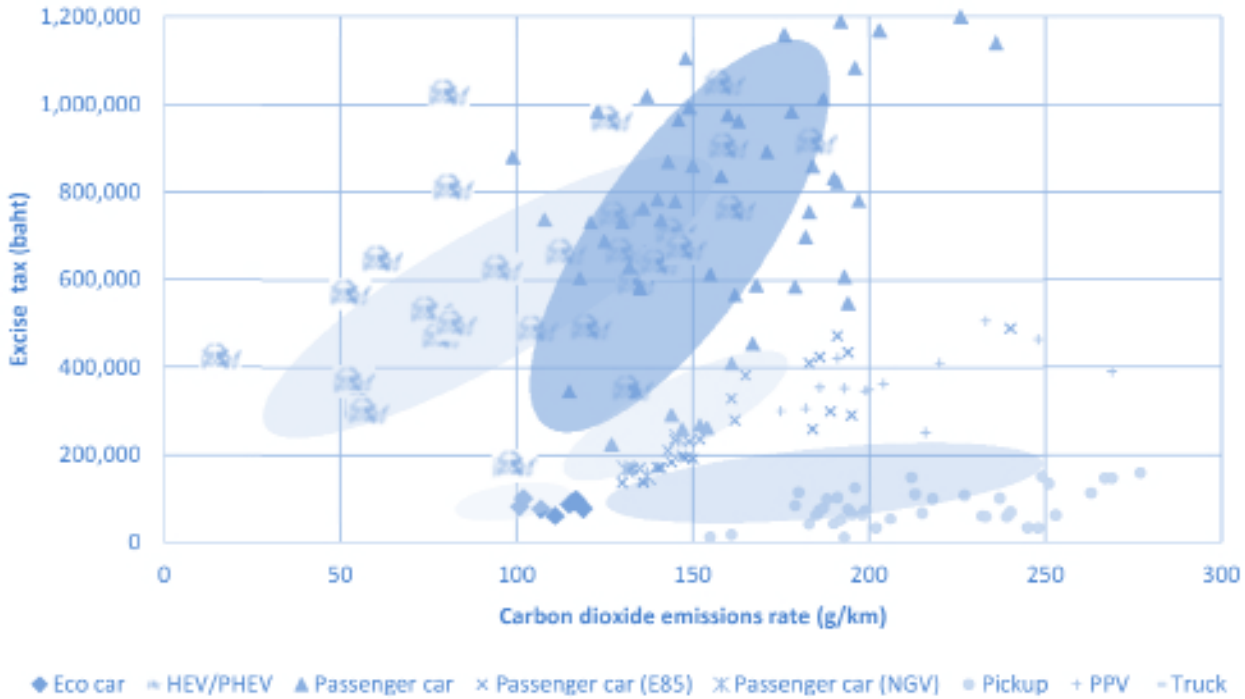
4. SUGGESTED POLICY DIRECTIONS FOR THAILAND

In order to survive the transition and capture emerging opportunities, Thailand should focus on bridging its industrial goal to link with its environmental goal, namely Thailand needs to become the region's producer and exporter of fuel-efficient, environmentally friendly automobiles.

To do so, the government needs to be careful not to pick winners too soon as it is still too early to know which of the next-generation technology types is going to win in the long-run. Instead, a safer bet is to formulate technology-neutral policies that reward low-emission automobile technologies, including efficient ICEs, HEVs, PHEVs, BEVs,

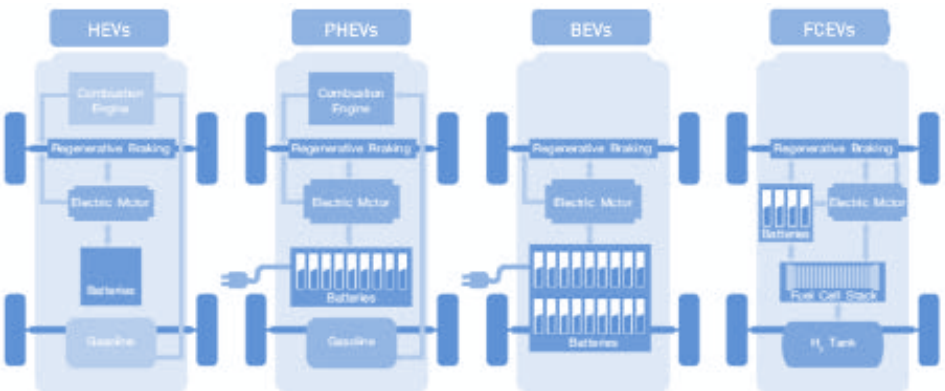
[4] *The "Eco-sticker" is an information tag detailing fuel efficiency, the environmental and safety qualifications of a car for the consumer's benefit. Developed by the Ministry of Industry and launched in 2015, it contains a variety of information, for instance, the fuel consumption rate and carbon dioxide emission rate.*

Figure 8: Average excise tax payment vs. carbon dioxide emissions (g/km)



Source: Office of Industrial Economics, Eco-sticker database. Accessed October 24, 2016.

Figure 9: Essential components of electric-engine automobiles



Source: King Mongkut's University of Technology Thonburi, and National Metal and Materials Technology Center (2015). "Assessment of Electric Vehicle Technology Development and Its Implication in Thailand," February 2015.

and FCEVs. We therefore propose the following strategies.

4.1 Supply-side strategy

Without the relevant technology in hand, Thailand should try to attract foreign investment in **essential components of the next-generation automobiles**, especially batteries and motors. Figure *9* illustrates that batteries and electric motors are common components for HEVs, PHEVs, BEVs, and FCEVs.

The goal is to position Thailand as a base for manufacturing batteries and motors in Southeast Asia. In this way, Thai manufacturers can capture

part of the high value added from the new supply chain and get benefits from technological transfer.

One form of financial incentives that can help attract foreign investment is to reduce/exempt import tariffs for components needed to produce batteries and motors. The current tariff structures for components of batteries and motors can be as high as 60 percent (WTO rate) and as low as 0-30 percent (FTA rate).[5] Even though the existing tariffs on components are not exceptionally high, reducing tariff on components still offers the benefit of lowering the purchase price and further boosting domestic demand.

One word of caution, however: the government should avoid taking a shortcut by reducing tariffs for importing completely built up (CBU) vehicles, that is, vehicles which are completely built outside of Thailand. Even though exempting tariffs on CBU vehicles can reduce the domestic price and boost demand for such vehicles, there will be no value added, nor will there be technology transfer opportunities remaining for domestic manufacturers.

Lastly, it is important to emphasize that this supply-side strategy has to complement the following demand-side strategies to be successful in attracting foreign investment.

4.2 Demand-side strategy

Demand-side strategies include any mechanisms that allow environmentally friendly vehicles to become more cost-competitive than traditional ICEs.

The first strategy is to revisit the existing automobile excise tax. As stated previously, the current excise tax structure does not fairly reflect the environmental footprint of each automobile. Thus, one obvious way to give a more competitive edge to the next-generation of environmentally friendly automobile is to recalculate the excise tax based on carbon dioxide emissions.

In Figures 10 and 11, we show that adjusting the excise tax can increase price competitiveness of environmentally friendly cars. We used Toyota Camry (ICE and HEV), Nissan LEAF (BEV), and Tesla Model 3 (BEV) as examples. We chose Toyota Camry because it is a popular HEV model with an ICE counterpart. We also chose Nissan LEAF and Tesla Model 3 as representatives of the BEVs since Nissan LEAF is one of the top-selling BEVs and Tesla Model 3 is positioned as a mass-market BEV that will be released in late 2017.

In this thought experiment, we calculate the life cycle cost of each vehicle. The life cycle cost includes up-front purchse price, lifetime fuel cost, and the newly calculated excise tax that reflects the environmental damage from the tailpipe carbon dioxide emissions.

> Life cycle cost = purchase price + NPV fuel + tax on carbon dioxide emissions

Lifetime fuel cost is calculated based on the assumption that each model of vehicle is driven about 3,100 km per month and has a useful lifetime of eight years. The new excise tax is based on the estimated lifetime carbon dioxide emissions of each vehicle multiplied by the social cost of carbon (SCC) at three levels of the discount rate.[6]

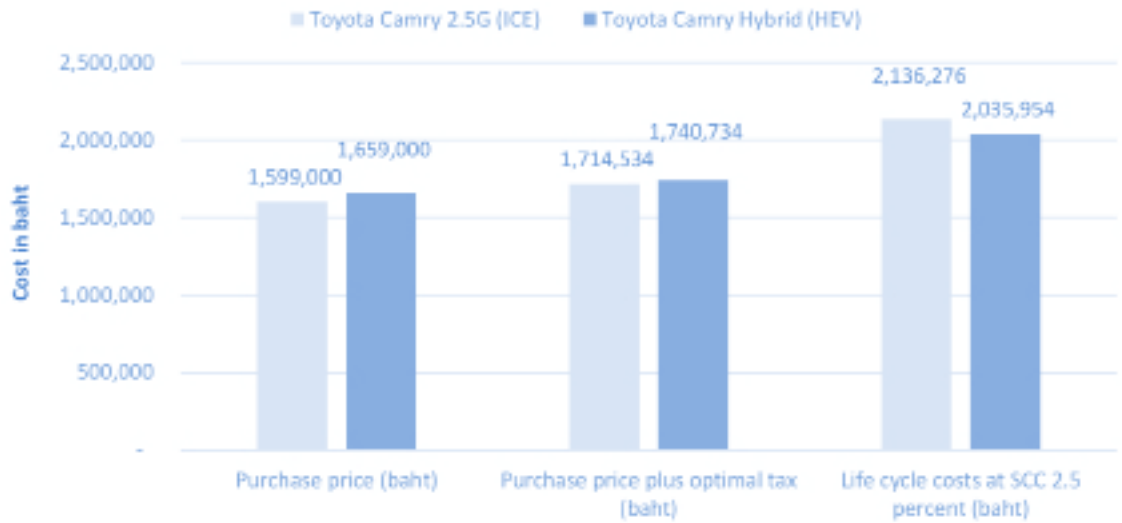
It may be noted that the newly calculated excise tax used in this thought experiment is *significantly lower* than the existing excise tax for these vehicles. This is because the existing excise tax reflects other government objectives than just the environmental objective. However, as long as this portion of the tax that reflects other objectives remains the same across relevant car models, the relative price differences calculated here will remain unchanged.

First, compare the Toyota Camry 2.5G

[5] *For more details, see the Thai Customs database [http://igtf.customs.go.th/igtf/viewerImportTariff.do?param=main].*

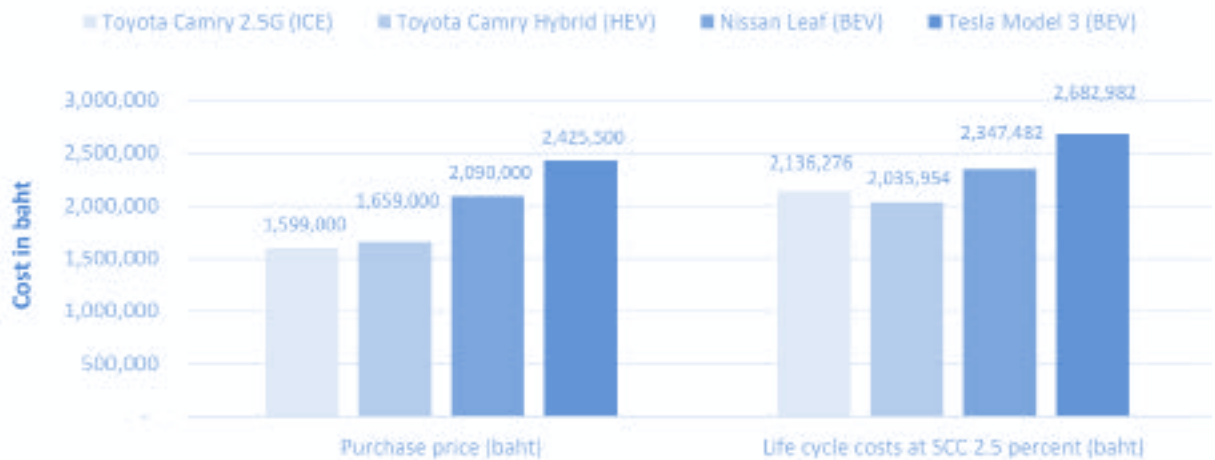
[6] *For detailed information on the calculations and the assumptions, please refer to Annex I.*

Figure 10: Life cycle cost of Toyota Camry with driving range of 3,100 km/month



Source: Authors' calculations.

Figure 11: Life cycle cost of Toyota Camry vs. Nissan LEAF (BEV) vs. Tesla Model 3 (BEV) at 3,100 km/month



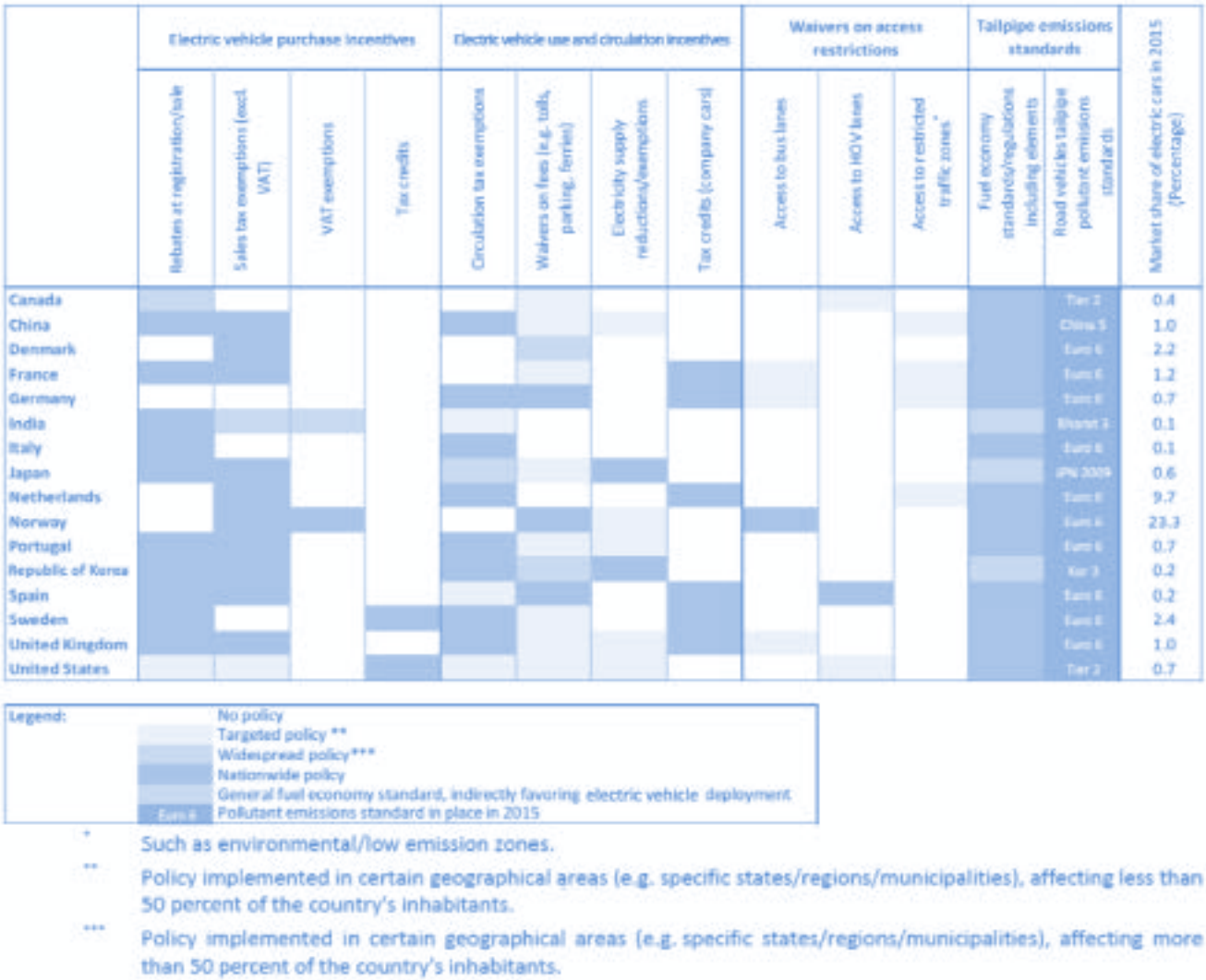
Source: Authors' calculations.

(ICE) to the Toyota Camry Hybrid in Figure 10. The purchase price of the Toyota Camry Hybrid is 60,000 baht more expensive than its ICE counterpart. However, when adjustment is made for the tailpipe carbon dioxide emissions ("purchase price plus optimal tax"), the Hybrid model now would cost only 26,200 baht more. Lastly, when adjustment is made for the tailpipe carbon dioxide emissions and the lifetime fuel cost ("life cycle costs at SCC 2.5 percent"), the Hybrid model becomes cheaper than its ICE counterpart by 100,323 baht.

This exercise shows that, with the proper tax structure that reflects environmental damage and consumers' awareness of lifetime fuel savings, the Toyota Camry Hybrid can easily become cost-competitive with its ICE counterpart without needing additional incentives.

Next, Figure 11 shows a comparison of the Toyota Camry with the Nissan LEAF and Tesla Model 3. Adjusting for the lifetime fuel cost and carbon dioxide emissions reduces the price differences between the BEVs and the ICE/HEVs

Figure 12: Summary of policy support mechanisms for electric vehicle uptake in place in selected countries in 2015



Source: International Energy Agency (IEA). "Global EV Outlook 2016: Beyond One Million Electric Cars."

("life cycle costs at SCC 2.5%"). However, the price premium for the BEVs is still significant, which suggests that additional incentives might be needed to make the cost of BEV competitive, which leads to the proposed **second strategy**.

The **second demand-side strategy** includes granting subsidies or tax incentives to consumers who purchase these environmentally friendly vehicles that are not currently price-competitive with traditional ICE vehicles. The purchase incentive scheme is a popular mechanism used in the United States, Europe, and Japan (see Figure 12). For example:

- *United States*: The United States government gives a maximum tax credit of $7,500 for grid-enabled vehicles (limited to the first 200,000 vehicles per manufacturer).

- *United Kingdom*: Customers who purchase BEVs receive a purchase incentive of up to £4,500 (or $6,300), while customers who purchase PHEVs priced below £60,000 (or $84,000) receive a purchase incentive equal to £2,500 (or $3,500).

Table 1: Subsidy required to make BEVs (Nissan LEAF and Tesla Model 3) price-competitive with an ICE (Toyota Camry)

	Purchase price (baht) [A]	Competitive price (baht) [B]	Subsidy required [A] – [B]
At SCC 5%	2,257,750	1,840,474	417,276
At SCC 3%	2,257,750	1,862,827	394,923
At SCC 2.5%	2,257,750	1,878,794	378,956

Source: Authors' calculations. The purchase price of BEVs is the average price of the Nissan LEAF and Tesla Model 3.

- *Japan*: Japanese purchase subsidies are calculated based on the price difference between an electric vehicle and a comparable ICE, with a maximum subsidy of $7,800.

In the next exercise, we calculate the amount of the subsidy (i.e., tax credits) needed to make BEVs (Nissan LEAF and Tesla Model 3) price-competitive with traditional ICEs (Toyota Camry 2.5G). We define the competitive price for a BEV to be the up-front purchase price that makes the life cycle cost of the BEV equal to the life cycle cost of the ICE.[7] In other words:

> Competitive price for BEV = life cycle cost of ICE - NPV fuel of BEV - tax on carbon dioxide emissions of BEV

The difference between the current purchase price for a BEV and the competitive price for a BEV is the subsidy needed to make the BEV price-competitive.

Table 1 suggests that *given the newly calculated carbon dioxide-based excise tax, the lifetime fuel cost, and the current BEV/ICE purchase prices, BEVs need an additional subsidy of about 400,000 baht per vehicle to be cost-competitive with a comparable ICE.*

[7] *Note that the lifecycle cost here includes the newly calculated carbon dioxide-based excise tax proposed previously.*

4.3 Software and automation: value-added opportunities that should not be overlooked

Assumed to be the largest automotive software developer in Southeast Asia, Thailand has huge potential to capture the value added from the software and automation trends required for the next generation of automobiles. This is due to the wage advantage of Thai computer engineers that attracted Japanese automakers to build their software units in Thailand approximately 10 years ago. Over time, the software units in Thailand have progressed from doing a single low value-added task to high-value tasks, such as managing the whole process from the design state to implementing, and testing of automotive software that controls the powertrain, especially for models that are assembled domestically.

Despite its prior advantages in software and automation in the region, Thailand is facing two major challenges in retaining human resources in this area. The first challenge is the rising wage competition from other domestic industries. Interviews with automotive software firms revealed that there are shortages of highly skilled computer engineers in the market. Talented engineers would opt for more highly paid positions in banking, consulting, or related industries. Existing engineers, especially those who are newly graduated, often need intensive in-house training and fail to perform up to their full potential in the first year of employment. The second challenge is the rising wage competition from Vietnam and the Philippines, which are producing equally highly

THERE ARE THREE MAJOR REASONS TO EXPECT SLOW ADOPTION OF BEVS IN THAILAND. FIRST, CURRENT BATTERY TECHNOLOGY CAN OPERATE ONLY FOR A LIMITED RANGE, AND IT TAKES A LONG TIME FOR VEHICLES TO CHARGE. THESE CONSTRAINTS MAKES IT DIFFICULT FOR BEVS TO SUIT THE VARIOUS RANGE OF TRANSPORTATION NEEDS IN THAILAND, ESPECIALLY IN VIEW OF THE EXISTING HEAVY TRAFFIC CONDITIONS.

skilled labor with comparable or even lower wages than that of Thai engineers.

Together, these challenges imply that the government needs to be more strategic about producing and retaining highly skilled labor in this area to fully take advantage of forthcoming opportunities.

4.4 BEV infrastructure: investing the right amount at the right time

In preparation for the transition, the government's initiative to invest in charging for the infrastructure needed for BEVs is a step in the right direction. However, the government should be careful not to invest too much too early, as we believe that a few more years will be required for BEVs to become widespread in Thailand.

There are three major reasons to expect slow adoption of BEVs in Thailand. First, current battery technology can operate only for a limited range, and it takes a long time for vehicles to charge. These constraints makes it difficult for BEVs to suit the various range of transportation needs in Thailand, especially in view of the existing heavy traffic conditions. Second, the cost of production and hence the purchase price of BEVs are still higher than most ICEs and HEVs. Lastly, the price of gasoline is projected to remain moderate over the next few years, making the purchase of BEVs less attractive.

Combine these facts with the results from section 4.2 on demand-side strategy, market trends emphasize the likelihood that HEVs will become mainstream automobiles in the short to medium term, while BEVs might phase in over a longer time horizon. Thus, the current effort to encourage investment in 100 BEV charging stations during the next three years might result in infrastructure that sits relatively idle for the next several years.

5. CONCLUSION

It is apparent that next-generation consumers are expecting much greener and smarter automobiles than the types available today. As an automobile exporter, Thailand has received a warning sign as its product champion, one-ton pickups, struggled to make sales in key markets with tightened new environmental standards.

The key to the survival of Thailand's auto industry is to align the industrial goal with the environmental goal. In other words, Thailand needs to become Southeast Asia's manufacturing hub for next-generation, environmentally friendly automobiles. The transition strategies include lowering tariffs for essential components for manufacturing electric batteries and motors, and giving price incentives to boost domestic demand for environmentally friendly automobiles. Moreover, the government should capitalize on

Table A1: Social cost of carbon value: 2017 (US dollars/metric ton of carbon dioxide)

Discount rate year	5% average	2.5% average	3% average
2017	11	59	39

the competitive advantage that Thai entrepreneurs have in the area of software and automation for automobiles. Lastly, given the likelihood that the market for BEVs will take some time to expand, we recommend that the government rethink the timing of its investment in BEV infrastructure.

Annex I

The interagency process that developed the original United States government social cost of carbon (SCC) estimates is described in the 2010 interagency technical support document of the Interagency Working Group on Social Cost of Carbon 2010. Through that process, the Interagency Group selected four SCC values for use in regulatory analyses. Three of the values are based on the average SCC from three integrated assessment models (IAMs), at discount rates of 2.5%, 3%, and 5%.

Assumptions

- All types of cars are designed to give satisfaction to consumers equally, but consumers consider only the life cycle costs of cars. Therefore, consumers decide to buy cars that must have the lowest costs throughout the life cycle costs.
- The project used in the calculation is determined according to the lifetime of the car. The performance of the car is determined by the lifetime of the battery, which can be used on average for eight years. So the calculation will be use a project life of eight years.
- Lifetime driven[8] = 1,500 and 3,100 km/month
- Discount rate MLR = 7%
- Exchange rate (2017) = 35 baht/US dollar
- Price of fuel (E20)[9] = 22.18 baht/liter
- Retail electricity rate = 4 baht/kWh.
- Energy cost rate:
  ICE = 0.08 liter/km
  HEV = 0.056 liter/km
  BEV = 0.198848 kWh/km
  For electric vehicle, assume 0.32 kWh/miles (100 km = 62.14 miles).[10]
- Price:
  Toyota Camry 2.5G (ICE) = 1,599,000 baht
  Toyota Camry (HEV) = 1,659,000 baht
  Nissan LEAF (BEV) = 2,090,000 baht
  Tesla Model3 (BEV) = 2,425,500 baht
- Current tax:
  Toyota Camry 2.5G (ICE) = 559,650 baht
  Toyota Camry (HEV) = 331,800 baht
  Nissan LEAF (BEV) = 209,000 baht
  Tesla Model 3 (BEV) = 242,550 baht
- Carbon dioxide (CO2) emissions:
  Toyota Camry 2.5G (ICE) = 188 g/km or 0.000188 metric ton/km
  Toyota Camry (HEV) = 133 g/km or 0.000133 metric ton/km
  BEV = 111.35 g/km or 0.000111 metric ton/km
- Discount rate SCC 2017:
  5% = 11.00 $/metric ton of CO2 or 385 baht/metric ton CO2
  3% = 39.00 $/metric ton of CO2 or 1,365 baht/metric ton CO2
  2.5% = 59.00 $/metric ton of CO2 or 2,065 baht/metric ton CO2
- The example vehicles used in the calculation are Toyota-Camry (ICE), Toyota-Camry (HEV), Nissan-LEAF (BEV) and Tesla Model 3

[8] *Lifetime driven = cost of fuel/(energy cost rate*price of fuel). Cost of fuel and energy cost rate are available from www.car.go.th.*

[9] *Authors' calculation by average price of fuel (E20) 2016 – January 2017.*

[10] *http://www.afdc.energy.gov/vehicles/electric_emissions_sources.html.*

Annex II

Tax based on carbon dioxide emissions = emissions of carbon dioxide (CO_2) (metric ton CO_2/km) * lifetime driven (km/year) * Social cost of carbon value (baht/ metric ton of CO_2)

Life cycle costs of cars = fixed cost (price) + net present value of fuel + tax based on CO_2 emissions

Table AII-1: Life cycle costs of cars (baht), 3,100 km/month

	Toyota Camry 2.5G (ICE)	Toyota Camry Hybrid (HEV)	Nissan LEAF (BEV)	Tesla Model 3 (BEV)
Life cycle costs at SCC 5%	2,042,282	1,969,458	2,291,809	2,627,309
Life cycle costs at SCC 3%	2,097,112	2,008,247	2,324,285	2,659,785
Life cycle costs at SCC 2.5%	2,136,276	2,035,954	2,347,482	2,682,982

Table AII-2: Life cycle costs of cars (baht), 1,500 km/month

	Toyota Camry 2.5G (ICE)	Toyota Camry Hybrid (HEV)	Nissan LEAF (BEV)	Tesla Model 3 (BEV)
Life cycle costs at SCC 5%	1,813,492	1,809,222	2,187,649	2,523,149
Life cycle costs at SCC 3%	1,840,022	1,827,991	2,203,364	2,538,864
Life cycle costs at SCC 2.5%	1,858,972	1,841,397	2,214,588	2,550,088

Competitive price for BEV = fixed cost of ICE (price) + NPV fuel of ICE + tax on emissions of CO_2 of ICE - NPV fuel of BEV - tax on emissions of CO_2 of BEV

Subsidy for electric cars = life cycle costs of ICE - life cycle costs of BEV

Table AII-3: Subsidy required for making BEVs (Nissan LEAF and Tesla Model 3) price competitive with ICE (Toyota Camry), 3,100 km/month

	Purchase price (baht) [A]	Competitive price (baht) [B]	Subsidy required [A] – [B]
At SCC 5%	2,257,750	1,840,474	417,276
At SCC 3%	2,257,750	1,862,827	394,923
At SCC 2.5%	2,257,750	1,878,794	378,956

Table AII-4: Subsidy required for making BEVs (Nissan LEAF and Tesla Model 3) price-competitive with ICE (Toyota Camry), 1,500 km/month

	Purchase price (baht) [A]	Competitive price (baht) [B]	Subsidy required [A] – [B]
At SCC 5%	2,257,750	1,715,842	541,908
At SCC 3%	2,257,750	1,726,658	531,092
At SCC 2.5%	2,257,750	1,734,384	523,366


ด้วยปฏิวัติข้อมูล
oosting the Thai Economy a

DATA REVOLUTION CREATING OPPORTUNITIES FOR BOOSTING THE THAI ECONOMY AND REFORMING GOVERNMENT SERVICES

INTRODUCTION[1]

The ongoing data revolution, together with the revolution in information and communications technology (ICT), is bringing about the emergence of "big data" and the data management revolution, including the opening of government data to new users. The data revolution furnishes various opportunities for driving Thailand forward. It can stimulate economic growth by increasing the productivity of the agricultural, manufacturing, and service sectors. The data revolution also creates an opportunity to reduce economic inequality by increasing transparency, reducing corruption, and redistributing income more effectively in targeting the poor. With an appropriate policy framework, the data revolution can help improve the people's quality of life. Moreover, the data revolution affords an opportunity to formulate better policies based on evidence rather than assumptions.

Nevertheless, all these opportunities will not happen automatically without the readiness of governmental agencies, businesses, farmers, labor, civil society, and the general public. Appropriate data policies are also needed to strike the right balance between disclosing individual-level data and maintaining privacy, and between opening up public data for general use and maintaining national security.

The theme of the recent annual academic conference organized by the Thailand Development Research Institute (TDRI) was on using the data revolution to boost the Thai economy and reform government services. It was held on March 13, 2017, at the Bangkok Convention Center, located in the Central World Complex. The presentations included concepts, examples and policy recommendations covering five topics. The following sections are summaries of each session of that conference.

DATA REVOLUTION AND OPPORTUNITIES FOR THAILAND[2]

By Dr. Somkiat Tangkitvanich

Humanity used to believe that the Earth was the center of the universe until early scientists collected data on the orbits of stars, which proved that belief wrong. Not until health pioneers generated mortality data, which helped identity the cause of disease and bring about changes in the field of public health, did it become possible to convince people that cholera could not be transmitted through the air. In the same way, mankind used to think that most soldiers were killed in combat until casualty records demonstrated that most military deaths occurred in hospitals, a finding which led to the evolution of hospital sanitation.

[1] *The session was translated by Ms. Mana Vitayakorn and Ms. Pimchanok Guarod.*

[2] *Summarized by Ms. Mana Vitayakorn and Mr. Kittiphat Buaubol.*

Not so long ago, Google's Computer Go beat a dominant professional player. A computer also defeated human experts on a game show, and computers are enabling cars to be driven without human drivers. Such capabilities are supported by four underlying technologies: sensors, big data, deep learning, and cloud computing.

Sensors are used to store real data in the corpus which amounts to big data, and these are then analyzed through deep learning; the knowledge is stored by cloud computing for later use.

Everything mankind encounters in this world comprises data. The opening of data to general users will bring about various economic benefits, such as Global Positioning System (GPS) data that in 2013 generated business and services worth more than US$ 56 billion.[3] Data have brought about social benefits, such as those used in tracking people, providing welfare, and monitoring government spending. Also, data are used to increase competitiveness, such as when selecting game players based on their aptitude.

Humanity is stepping into an information economy. If technologies are combined with existing data, new economic systems can be created.

- Manufacturing technology together with sensor data will create "Industry 4.0"
- Agricultural technology together with sensor data will create precision farming
- Financial technology together with transaction information will create "FinTech"
- Energy management technology together with electricity consumption data will create a smart energy management system

It is true that Thailand has collected weather data and satellite images, yet dissemination of such data remains in old-fashioned paper-based formats. Although some data are disseminated on line, they are subject to a time delay and are out of date. What is more, for some data there are discrepancies with reality. For example, a land title deed may be inconsistent with the Geographic Information System (GIS) map concerned, thus causing overlapping territorial claims. Such evidence suggests that Thailand still lags behind in data development.

Most data currently stored are merely virtual data. However, what is to come in the future would deal with real data and big data use, which are priceless. This introduces the notion of "Data 4.0," where Data 1.0 refers to data in the form of reports, which lack reliability and are largely undisclosed in Thailand. Data 2.0 includes data from surveys, which are rather scarce and costly in Thailand. Data 3.0 refers to a large volume of virtual data which Thai private sectors have begun to collect, but for which no clear mechanism yet exists for providing support from the government. Lastly, Data 4.0 is so-called big data, which refers to extremely large volumes of data that have not been adequately captured in Thailand.

There are many challenges that Thailand is currently facing, namely insufficient data utilization, lack of understanding of the use of data, undisclosed data, outdated data policies and laws, and shortage of manpower for dealing with data. By overcoming such challenges, the data revolution would create opportunities for Thailand to increase economic growth, reduce inequality, improve the people's quality of life, and formulate good policies.

DATA REVOLUTION FOR AN INFORMATION ECONOMY

By Dr. Somkiat Tangkitvanich and Dr. Saowaruj Rattanakhamfu (TDRI), with guest speakers Mr. Pawoot Pongvitayapanu (CEO and Founder, TARAD.com) and Mr. Teeraboon Ariyasuthiwong (Managing Director, Longkong Studio Co., Ltd.)

[3] *http://gpsworld.com/the-economic-benefits-of-gps/*

Data comprise a crucial factor of production in the information economy. In addition, data can increase the productivity of other factors of production, such as land, labor, capital, and knowledge. As a result, data are becoming an indispensable element in wealth creation. For example, of 183 "unicorns" (start-up companies with a valuation exceeding US$ 1 billion) around the world, almost all are involved in data-intensive or data-management businesses, such as Uber, Airbnb, Snapchat, and Dropbox.

Data can help in creating new businesses in various ways, such as by making possible innovative pricing strategies (as in the case of setting car insurance premiums based on driving behaviors) or by helping to create new business models (as in the case of "FinTech" services). However, we argue that the quickest and biggest wins for Thailand in the use of data would not come from such innovative business models but from an increase in productivity across all sectors.

An example of such a quick win is the SCG Logistics Management Company's use of data to reduce energy costs. The company has utilized temperature data to decrease the use of energy consumption in its cold-chain storage by appropriately adjusting the air-cooling system in accordance with outside temperatures. Without making additional capital investment, the company's monthly energy cost has been reduced by 200,000 baht, which represents about 17 percent of the total energy cost of its cold-chain storage.

The agricultural sector in Thailand has also started to use data to increase its productivity. For example, Mitr Phol Group, a global leader in sugar production, has utilized data to increase productivity at its sugarcane plantation in Phu Khieo District, Chaiyaphum Province. Pieces of land are consolidated into large plots to accommodate the use of machinery, such as sugarcane harvesters. The distance between individual sugarcane plants is adjusted so that they are 1.85 meters apart from each other. Large agricultural machinery and other related equipment are controlled by a GPS system to decrease crop damage, prevent soil compaction, and reduce unnecessary tillage, which leads to an increase in sugarcane output and the ability to plant and harvest sugarcane in time for refining. The use of data also improves logistics management by reducing transportation time, which in turn helps increase the sugar content of the harvested sugarcane.

Mitr Phol Group also uses data from various sources to forecast sugarcane production by utilizing satellite imagery and GIS maps to measure sugarcane cultivation areas. Workers in sugarcane plantations use their tablets or smart phones equipped with GPS to locate their cultivated areas and collect necessary data, such as the types of sugarcane planted and periods for planting and fertilizing. Data on sugarcane crop growth monitored by drones and weather information in each area are also collected. All these data are estimated by a model to forecast sugarcane yield more accurately, enabling the company to enter into futures contracts for sugar with confidence.

The manufacturing sector in Thailand has also started using data to increase productivity. For example, in the printing business, Siri Wattana Interprint Company uses operational data to solve many management problems, such as the mismatches between printing presses and types of printed work, and high inventory costs. The company has also developed an information system to manage printing orders and monitor the working status of printing machines, and it set up a "war room" to monitor and manage all its production processes.

Among all economic sectors, the service sector uses data most intensively. For instance, All Thai Taxi utilizes data to solve problems of taxi drivers and passengers by reducing non-revenue-

generating time, saving fuel cost, decreasing accident rates, and increasing service quality. In particular, the company makes use of taxi location data to match nearby taxi cabs in order to speed up the shift-changing process. The company also provides data on routes and locations with high concentrations of potential passengers to reduce taxi drivers' idle time. To improve the quality of its service, the company applies a GPS tracking system to monitor the driving behavior of taxi drivers. As a result, passengers feel more secure because taxi drivers can neither overcharge them nor refuse to provide service.

In the construction business, the Builk software package helps increase the productivity of contractors by providing them with a free construction accounting program. By adopting this software, contractors can shorten their construction period and calculate their project costs more quickly. Accordingly, they can reduce direct and overhead costs and thus increase their profit.

The above-mentioned case studies show that data can increase productivity in the agricultural, manufacturing and service sectors. An improvement in total factor productivity (TFP) is a result of increased output and revenue, while inputs increase at lower rates or even decrease in some cases.

- The Mitr Phol Group has increased its total factor productivity by 34 percent, with a 43 percent increase in output, 7 percent decrease in labor cost, 12 percent increase in capital cost, and 10 percent increase in raw materials cost
- Sirivatana Interprint has increased its total factor productivity by 6 percent, with an 82 percent increase in output, 60 percent increase in labor cost, 75 percent increase in capital cost, and 81 percent increase in raw material cost
- All Thai Taxi has increased its total factor productivity by 18 percent, with a 24 percent increase in output, 15 percent decrease in raw material cost, and 23 percent decrease in capital cost
- Construction companies using Builk's software have increased their total factor productivity by 26 percent, with a 23 percent increase in output, 2 percent decrease in labor cost, and 3 percent decrease in capital cost

To estimate the economic impact of data use, it is assumed that data usage in the agricultural, manufacturing, and service sectors across the board has resulted in a modest increase in total factor productivity of 20 percent in each sector in terms of the above case studies. In particular, the TFP for each of the agricultural, manufacturing and service sectors was assumed to increase 6.8 percent, 1.2 percent, and 4.8 percent, respectively. The estimation based on the computable general equilibrium model shows that Thailand's gross domestic product would increase by 0.82 percent, or 81 billion baht, just by making good use of data.

A workforce sufficiently qualified in the data area is key to creating an information economy. A 2016 survey by the National Statistical Office (NSO) found that there are about 81,000 workers employed in data-related jobs, consisting of 11,000 specializing in mathematics/statistics, 47,000 in software development, and 23,000 in related IT jobs. In the past five years, on average, the pool of these data-related employees increased by about 7,300 per year, while as many as 23,000 students per year graduated from universities where they took subjects in the related fields. As such, the number of persons in the data-related workforce in Thailand grows at only one-third of the annual number of new graduates, which implies either a mismatch between the skills of the graduates and market demand, or graduates of poor quality.

To summarize, a quick win in boosting the Thai economy is through applying data to increase

productivity. In most of the above-mentioned case studies, the data used to increase productivity already existed in the related companies. Wisely utilized, existing data can help increase the productivity of companies. Large companies are generally in a good position to make use of their data. They should do so and should also help small and medium-sized enterprises (SMEs) in their supply chains to utilize data, as exemplified in the case of the Mitr Phol Group, which helps its sugarcane farmers to apply data for productivity improvement.

The public sector can play many crucial roles in promoting data utilization, such as raising awareness of the benefit of using data among the private sector, subsidizing SMEs and small-scale farmers in developing their own data systems, and collecting and publishing up-to-date and accurate data. The government should not try to seek revenue from selling the data gathered with taxpayers' money. Instead, it should disclose important data sets, such as business registration data, weather information, transportation timetables, land-ownership data, and agricultural prices, in forms that are machine readable and free of charges.

Finally, Thailand should accelerate its development of a data-related workforce. In particular, universities should revise their curricula to meet market demand and provide "dual education" by working closely with the business sector so that students can learn from real-world problems. The government should also support the private sector in producing a workforce in data fields through the mechanism of joint scholarships. To meet shortages in the short run, foreign workers with expertise in the data fields should be allowed to work in Thailand.

IMPROVING QUALITY OF LIFE THROUGH THE DATA REVOLUTION[4]

By Dr. Worawan Chandoevwit, Dr. Wichsinee Wibulpolprasert, and Mr. Nuthasid Rukkiatwong (TDRI), with guest speaker Assoc. Prof. Dr. Agachai Sumalee (Smart City Research Center, King Mongkut's Institute of Technology Ladkrabang)

Public services play a critical role in every stage of human life. Even though public services are provided to all people, their quality is still a major concern. In the era of information technology, data are key to improving the quality of public services and upgrading the quality of life for the Thai people.

During childhood, data and technology can be used to improve the quality of schools. Thailand's concern about good-quality education has been heightened due to the fact that a large proportion of Thai students scored below the international baseline of the PISA[5] science test. One of the reasons is that Thai parents have limited

[4] *Summarized by Ms. Wannapha Kunakornvong and Mr. Phasith Phatchana.*

[5] *PISA (Programme for International Student Assessment) is a global study conducted by the Organisation for Economic Co-operation and Development (OECD), in which 15-year-old students' scholastic performance in mathematics, science, and reading is assessed.*

information on school quality and thus make decision when selecting schools for their children based on the physical and environmental conditions of schools, such as the number and appearance of school buildings. Under the circumstances, open data on school quality can help parents make better decisions while increasing competition among schools in order to improve their quality. Linking data from various sources is also useful to overcome administrative and management problems. Through mobilization and utilization of shared resources among small schools in nearby areas, the "Kang Chan Model" (K-C model) has successfully addressed teacher shortages, resulting in significant improvement in student learning. Currently, the K-C model has been conceptually adapted by the Ministry of Education for replication in other areas.

For the working-age population, using good-quality data can help not only in improving the education system in Thailand but also in responding to labor market demands. Labor market studies in Thailand face a number of methodological and administrative challenges, as revealed by NSO. According to NSO, the labor demand survey has been constraint by high survey costs and hence fixed sample frame/size and data quality. To improve the survey's quality, data from online job announcements are used to analyze target markets and skills. For example, in a study conducted by TDRI on skills needed in the labor market, of 100,000 job announcements collected by the National Electronics and Computer Technology Center (NECTEC) 10,000 were randomly selected to construct a skills demand database. These online data were then used to produce deeper insights about the skills needed in different occupations while reflecting on the reality of labor market situations. Further, online job announcement data can support educational institutions in designing and enhancing curricula to meet labor market demands.

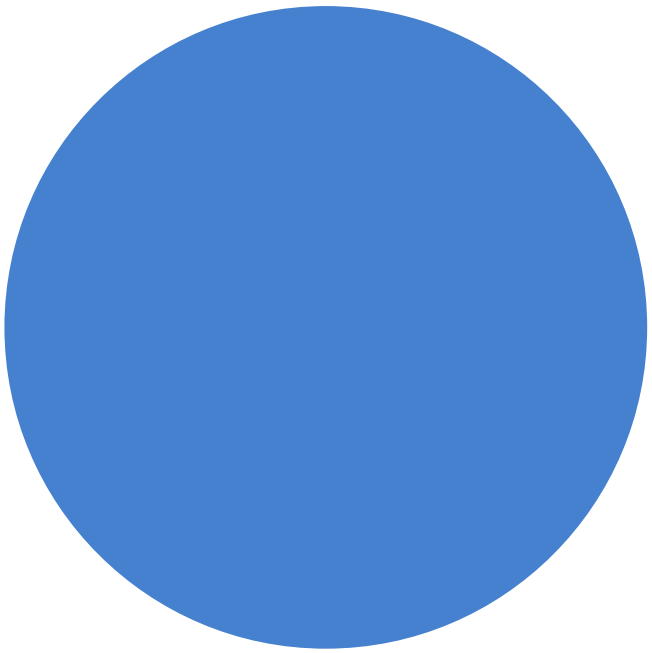
For all age groups, big data are potentially useful for improving people's quality of life by reducing health risks and the risk of early death. Synchronization of data from various sources can reflect real situations. For example, by synchronizing health data and civil registration data, it was found that Thailand's maternal mortality ratio (MMR) is much higher than had been previously perceived, and still far from achieving one of the targets of the Millennium Development Goals. The MMR also reveals health inequalities among population groups based on geographical and age differences. For example, the MMR in the southern region of Thailand is four times higher than that in Bangkok and its vicinity, which is similar to the ratios measured in Egypt and Tunisia. Thus, data management and analysis processes, including data collection, synchronization, open data, and data analytics, are contributing significantly to the effective planning and management of health resources.

To reduce the risk of traffic accidents, the private sector — for example, All Thai Taxi — has virtually integrated three important devices, namely engine, speed and GPS, to determine risk factors. A recent study revealed that key risk factors associated with traffic accidents are unsafe driving behaviors, car performance, and road conditions.[6] Similarly, the Department of Land Transport has collected data on driver behavior through personalized identification cards and GPS sensors. To detect and measure related risk factors for car accidents, GPS has been installed in public transport vehicles, and their drivers are observed through personal data collected automatically. Synchronization between public and private data will enable the agencies concerned to effectively assess areas at risk and facilitate further study on specific issues of policy interest.

In summary, data collection, synchronization,

[6] *http://bhs.doh.go.th/statistic/cause*

FOR ALL AGE GROUPS, BIG DATA ARE POTENTIALLY USEFUL FOR IMPROVING PEOPLE'S QUALITY OF LIFE BY REDUCING HEALTH RISKS AND THE RISK OF EARLY DEATH. SYNCHRONIZATION OF DATA FROM VARIOUS SOURCES CAN REFLECT REAL SITUATIONS.



open data, and data analytics are key data-related processes for improving public services and increasing the quality of life for all people. Such challenges as different data formats, lack of data scientists, and privacy issues require appropriate strategies and actions by the government.

DATA FOR CREATING A FAIR SOCIETY[7]

By Mr. Chanon Techasunthornwat (Faculty of Economics, Thammasat University) and Mr. Tippatrai Saelawong (TDRI), with guest speaker Asst. Prof. Dr. Thanee Chaiwat (Faculty of Economics, Chulalongkorn University)

The afternoon sessions started with a presentation on social injustice. Generally, social injustice comes in various guises, including forms of social inequality and corruption. In the session entitled Data for Creating a Fair Society, the speakers discussed and illustrated how big data and open data as well as machine learning technology could help in addressing social injustice issues.

Big data can promote social justice through the provision of more accurate data for policy-making. An example is the application of high-resolution satellite imagery data to improve the process of targeting poverty. By locating some proxies, such as types of household roof and road conditions, using satellite images, one can identify poor areas or households living in poverty. Such data can also help reduce inclusion error from poverty targeting by comparing proxies for areas that are not poor with locations of welfare-for-the-poor recipients. If there is a concentration of welfare recipients in non-poor areas, it could be possible that the poverty alleviation program has misidentified non-poor households as poor.

Apart from satellite imagery data, cell phone data are potentially helpful for targeting poverty. Cell phones record such data as the duration of calls, calling costs, and locations. These data provide additional information for tracking poverty. In comparison with data obtained via satellite, cellular data, with frequent updates, have higher potential for accurately locating areas where help is needed most following disasters.

Beyond poverty issues, the availability of big data and open data can also help Thailand in detecting corruption risks and incidents in the public sector. Researchers at TDRI focused on identifying and detecting fraud in government procurement by using competitiveness as a proxy to determine corruption in the system across governmental agencies. Open data also revealed the fact that the government's new e-bidding system can increase price competition and reduce costs to the government.

Whereas big data and open data are necessary for Thailand to move toward a fair

[7] *Summarized by Mr. Chayathorn Termariyabuit, Mr. Kantaphon Amornrat, and Mr. Chakorn Loetnithat.*

and just society, one key element also needed for building a just society is an active citizenry. Dr. Thanee's research using mobile visual novel style games has led to the conclusion that incentives in the current system, rather than attitudes or moral grounds, play a major role in shaping susceptibility to corruption. Apart from building solid databases of big data and open data, it is therefore necessary for the Thai government to create a system in which active citizens are encouraged to engage, cooperate, and take part in helping Thailand become a fair and just country.

GOOD POLICIES THROUGH GOOD DATA AND GOOD DATA THROUGH GOOD POLICIES[8]

By Dr. Deunden Nikomborirak and Mr. Chatra Kamsaeng (TDRI), with guest speaker Mr. Worapoj Wongkitrungruang (Executive Editor of Openworlds Publishing House)

Big data, which have immense potential to improve society, are made up of a massive amount of versatile data that are constantly changing and being updated. Big data can be used, among other vital applications, to elevate a country's economy, improve living standards, alleviate poverty, and combat corruption. As a major data producer, user, and facilitator, the government must push through more data management reforms to adequately support a data-driven society in order to secure the greatest benefits from big data.

The Government as Data Producer

The Thai government constantly produces and possesses a large amount of data, such as citizen information, economic information, geographical information, environmental information, government procurement information, and legal information. Such a large bulk of data has both commercial and social value, but remains underutilized and difficult to access.

Of 92 countries in the Open Data Barometer's implementation rankings, Thailand currently ranks 56. While some government data are publicly available, much of the data are not in a computer-friendly format. In cases where more data should be and can be made available, the main obstacles to information disclosure include unwillingness of state agencies to be held more accountable, the poor quality of existing data, and possible legal repercussions associated with data disclosure.

The experiences of other countries suggest that open data initiatives often start from the top level. A prominent example is the United States Open Government Initiative, the brainchild of former President Barack Obama, who set out from his first day in office to create an "open and transparent government." His subsequent Open Government Directive was issued to instruct government agencies to adopt the "presumption of openness" principle, which means that all government data must be publicly available unless they fall within certain exemptions.

Thailand should consider learning from the experience of others and adopt a national open government initiative. Such an initiative could include the adoption of the "presumption of openness" by all government agencies in addition to data standardization and storage practices. Stakeholders, such as academics and journalists, should be involved in order to increase transparency and participation, and to promote efficiency and effectiveness in government.

The Government as Data User

Government functions and policy-making decisions require updated and comprehensive

[8] *Summarized by Mr. Sasipong Suma, Mr. Natchapol Praditpetchara, and Mr. Jirawat Suriyashotichyangkul.*

THE GOVERNMENT SHOULD CREATE A PARTICIPATORY AND INCLUSIVE ENVIRONMENT FOR PUBLIC INVOLVEMENT IN POLICY-MAKING, PARTICULARLY THROUGH COMMUNICATION TECHNOLOGY. FOR INSTANCE, THE UNITED KINGDOM HAS A WEBSITE WHERE THE GOVERNMENT CAN DIRECTLY COMMUNICATE WITH THE PUBLIC AND VICE VERSA.

information in order to enhance their efficiency. As previously mentioned, the Thai government possesses a large amount of data, but much of those data remain underused. One of the main reasons is that data often are not streamlined across government agencies. For instance, due to disintegration of data and information, land reform policies often overlap with those concerning protected areas, thus contributing to ineffective policy implementation. Therefore, it is imperative that the Thai government should establish or designate an independent body to streamline information across government agencies in order to efficiently minimize overlapping policies and functions.

Furthermore, the government should create a participatory and inclusive environment for public involvement in policy-making, particularly through communication technology. For instance, the United Kingdom has a website where the government can directly communicate with the public and vice versa. The website also provides a platform for the public to petition the government directly.

The people of Thailand have recognized the importance of participation and are interested in engaging in the policy-making process, although no official communication channel is available. In 2016, for example, a large number of people protested against the Computer Crime Act via a Change.org petition which attracted more than 300,000 signatures. With considerable public interest, the government should consider reviewing the "Rule of the Office of the Prime Minister on Public Consultation, B.E. 2548 (2005)" in order to facilitate an authentic participatory process.

The Government as Facilitator of Data Use

Whereas data disclosure benefits both the public and private sectors, protection of personal privacy must be taken into consideration. Currently, regulations governing personal information are ambiguous, resulting in misconduct, non-compliance, and discrepancy in implementation between the private and public sectors. Specifically, government agencies must abide by the Official Information Act, B.E. 2540 (1997), which states that disclosure of personal information is prohibited. However, the lack of clear definition of personal information discourages government officials from releasing even non-personal information because of speculative or abstract fears, whereas such reluctance does not prevent the private sector from information disclosure.

Currently, many countries are amending their domestic legislation to facilitate greater utilization of data while still honoring individual privacy. For instance, Japan classifies personal information into three risk-based categories: anonymized personal data; general personal data; and sensitive personal data. While anonymized data can be fully utilized, personal information in the latter two categories may be used only with the consent of the owner and only for certain purposes. To facilitate the productive and appropriate utilization of information, the Thai government should clearly define personal information and regulate its usage based on information sensitivity. Such an approach will establish a standardized system for improving the effectiveness of information disclosure.

THAILAND'S NATIONAL AGENDA ON DATA: WHO NEEDS TO DO WHAT?[9]

At its 2017 annual conference, TDRI convened a panel discussion on "Thailand's National Agenda on Data: Who Needs to Do What?" The panelists were Mr. Chen Namchaisiri, President of the Federation of Thai Industries; Mr. Teeranun Srihong, President and Chairman of

[9] *Summarized by Mr. Supanutt Sasiwuttiwat, Mr. Sunthorn Tunmuntong, and Ms. Urairat Jantarasiri.*

Kasikorn Business-Technology Group; Mr. Siriwat Vongjarukorn, President and Chief Executive Officer of MFEC Public Company Limited; and Dr. Prawit Leestapornwonsa, M.D., Commissioner of the National Broadcasting and Telecommunications Commission (NBTC). The discussion was moderated by Dr. Nattha Komolvadhin, News Editor and Anchor of the Thai Public Broadcasting Service (ThaiPBS).

Data as the Petroleum of the Future

The panelists agreed that the modern economy is being transformed and driven by big data and data technologies. In order to maintain and improve Thailand's economic competitiveness, Thai businesses and other sectors urgently need to catch up with new developments in this field. One of the most transformed sectors is manufacturing. Mr. Chen gave as an example the case of big data in the garment industry. Instead of mass-producing clothes in standard sizes (S, M, L, XL), a Thai manufacturer hires tailor shops to measure customers' body size and shape. The data are then sent to automated factories where production machines read the data and produce clothes to fit each customer's body and shape.

With big data on customer behavior, businesses can also set new pricing strategies. This was illustrated by Mr. Teeranun's work experience at Kasikorn Bank (K-Bank), which is now a leader in the credit market for SMEs. During the 1997 financial crisis, K-Bank collected large amounts of data for calculating companies' credit risk scores. Strikingly, it was found that many high-risk companies received low-interest loans while high-interest loans were offered to low-risk businesses. With those data, K-Bank redesigned its loan packages, using interest rates that properly matched companies' risk levels.

Mr. Teeranun emphasized: "Data is the future petroleum – the future economy will no longer be shaped by crude oil (petroleum), but data and knowledge generated from these data."

Utilizing Big Data is the Only Solution for Disrupted Businesses

Mr. Siriwat shared his experience in helping companies in industries disrupted by new technologies to recover. LOVEiS, a music company, lost its main revenue stream because consumers turned to free music available on YouTube. Fortunately, the company has many famous artists who are followed by about 5 million fans on social media. By analyzing the fans' music preferences, the company could arrange events that serve the fans' moods, while also encouraging them to subscribe to additional services, such as mobile banking. The company is now earning a new revenue stream from its contribution to the growth of other companies' customer base.

Matichon Group is currently the top Thai newspaper on social media, with more than 60 million views per month or 2 million views per day on Facebook Live. With its expanding follower

base and views on social media, the company recovered its revenues and has high potential to earn a lot more from advertisements on Facebook.

Dr. Prawit added that telecom companies are also looking at "Big Data Monetization," i.e. how to generate revenue from their large amount of data in order to compensate for the declining growth of mobile phone users.

Big Data Improve Public Services

Big data and data technologies can improve the quality of life, which the Thai state and society should learn to do. As Dr. Prawit said, many countries improve their public services by utilizing mobile data use. For example, South Korea could prevent the spread of epidemics into the country by examining whether data exist on people arriving in the country concerning their previous visits or residence in countries with epidemic risks. By tracking patients' mobile phone use, African countries predicted the direction in which ebola and malaria would likely spread, and thus they were able to effectively prepare prevention plans. In addition, countries in Africa could identify poor areas by considering the density of 2G package users and provide free buses in such areas.

Dr. Prawit suggested that Thailand could do the same, by using data on mobile top-ups of 10 baht or less per time to identify poor areas.

Challenges of the Data Revolution in Thailand

Compared with several other countries, Thailand is not utilizing data to their full potential; it cannot catch up with the advancement of information technology and the vast amount of data being stored. Mr. Teeranun gave the example of Kasikorn Bank, which uses only 15 datasets to predict credit risks, compared with the Chinese financial firm "WeLab," which uses a thousand-parameter data set and shorter time for credit approval. Such underutilized data as in the case of the financial sector can also be seen in the Thai manufacturing sector. Most entrepreneurs in the country have yet to fully utilize data both inside and outside their factories – customer behavior, export and import price comparison, and shelf value, for instance – to improve their competitiveness.

Regulations concerning data openness also have effects on competition in the market. Mr. Teeranun said that data are now the key to competition. "As long as the data remain protected, big companies that possess the data will continue gaining the upper hand." Currently Thailand still lacks a central database that is trustworthy and accessible with established regulation. This impedes SMEs from improving their competitiveness.

Moreover, data professionals are still greatly needed in Thailand. Mr. Siriwat added that "the key input of the data industry is human," as the number of data scientists in the market is very few. This situation is partly due to the limited opportunity to use data in the country, compared with Silicon Valley, where many skillful Thai data professionals have gone to work because working there enables

them to maximize their capabilities. In addition, machine builders and system integrators are also in demand in the manufacturing sector, said Mr. Chen.

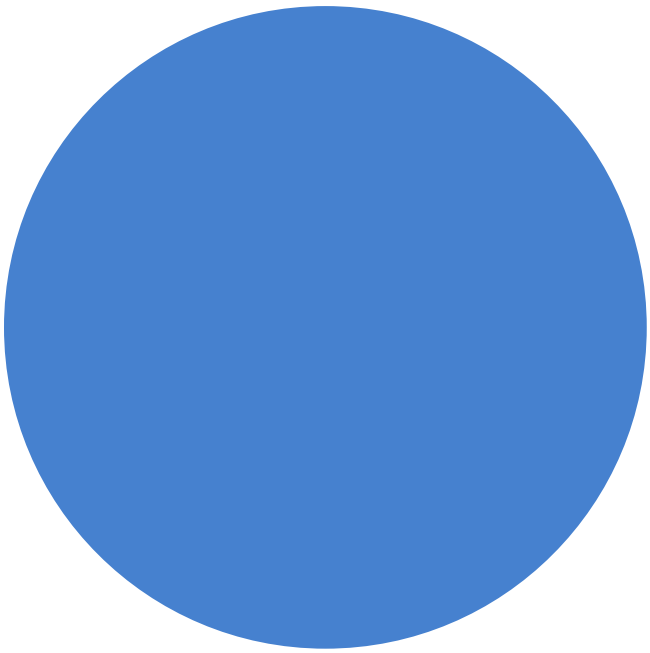
Another side of data openness, however, is the privacy of data owners. Since data and information have become a new asset, privacy and data ownership have become a "gray" area. Dr. Prawit said there have been cases of cybercrime and personal data abuse in many countries, including Thailand. This situation highlights the risks of having vast amounts of data collected and stored.

Thus, there have been attempts by nations, led by European countries, to effectively control the use of databases. For example, database accessibility in Europe is designed on the privacy-by-default principle, requiring the consent of data owners before use can be made of the data. In addition, accessible data must be anonymous and unidentifiable. Dr. Prawit added that NBTC's current regulation governing the use of personal information also stipulates that the data owner's permission is required before the data can be processed by others.

Key Recommendations for the Government and Businesses

The panel discussion concluded with four recommendations that would help the public and private sectors to prepare for the data revolution.

First, the national database should be established by a government agency which would also collect, store, clean, and manage data accessibility. It does not matter whether the agency is a statutory body or independent committees, as long as it is trustworthy and transparent, and able to preserve integrity and confidentiality. Examples of data stored in such a database would be financial data, mobile device data, and e-commerce data. The benefits and costs should be set for data users and contributors in order to properly maintain the system.



Second, data-related regulations should be revised and further developed. The government needs to create a good balance between data disclosure and privacy protection. This would include drafting a personal data law in order to cope with the growth of personal data related to people's daily life. Experimenting in a "sandbox" could be used as a trial for learning and development, instead of introducing comprehensive legislation which covers all issues but cannot be enforced effectively.

Third, a workforce with suitable data skills should be developed, especially data scientists, machine builders, and system integrators in the manufacturing sector.

Finally, the private sector should collect data both on production lines by investing in machines with IT capabilities, and other information, for instance, that on shelf value and customer behaviors. Offering incentives is a strategy to obtain data from customers. Moreover, businesses should use data to come up with a new business model that could save them from disruption of their normal functioning.