GASOLINE DEMAND AND SAVING MEASURES DURING CRISES FOR THAILAND

by
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ABSTRACT

Switching to other fuels and renewable energy in response to an oil shortage or rapidly raised oil prices is a good option for sustainability. The study focuses specifically on oil saving measures as another method to cope with a crisis in the transportation sector, and it applies to any types of fuels. The study incorporates an energy contingency plan with E4 perspectives of energy, economy, equity, and environment as well as a human ecosystem model to analyze 9 oil saving measures implemented in several countries. In addition to the information from other countries' experiences, policy recommendations for Thailand are identified based on an econometric analysis of gasoline demand in Thailand and evidence from a Thai online discussion forum and related articles. It is found that gasoline price is inelastic and each region has its own characteristics which the government should take into account when making a national plan. All the measures require cooperation among government units, the private sector, labor unions, and others involved in successfully implementing the plan. In order to increase the effectiveness of the measures and sustain the less fuel intensive behaviors, infrastructures, agreements, regulations, social norms and other barriers must be addressed. During a crisis, the synergistic effects among the saving measures, side effects, public information strategies, tailored information, technology utilization, monitoring and assessing of the situation, and the ability to make a quick adjustment of the plan are vital.

Chapter 1

INTRODUCTION

1.1 Background

Many nations are attempting to shift towards alternative energy because of concerns about energy security and greenhouse gas emission reduction. The Organization for Economic Co-operation and Development (OECD) estimates that based on the new policy scenario (or baseline scenario), the share of the world's renewable energy (hydro, bioenergy and other renewables) will increase from 13% of the world's primary energy demand in 2013 to 18% of the demand in 2040 while the share of oil consumption will decrease from 31% in 2013 to 26% in 2040. However, the absolute value of oil demand is expected to grow from 4,219 million tons of oil equivalent (Mtoe) in 2013 to 4,735 Mtoe in 2040 (Organization for Economic Cooperation and Development, 2015). This implies that oil still plays a significant role in the world energy consumption. Although some researchers posit that electric vehicles and other alternatives will play important roles in reducing fossil fuel dependence and mitigating carbon emission (Jacobson & Delucchi, 2011; Brown, 2011), a high penetration of renewable energy is questioned by some analysts because of the problems of variability, availability, investment cost, etc. (Trainer, 2012). Moreover, OECD predicts that **oil will still play a major role,**

especially in transportation which accounts for 85% of world demand in the sector, in 2040 even though its share is predicted to decrease from 93% in 2013 (OECD, 2015).

According to Thailand's Alternative Energy Development Plan 2015-2036 (AEDP 2015), the country's target is to escalate the share of renewable energy consisting of heat, power generation, and biofuel in its total energy mix from 11.9% in 2015 to 30% in 2036. For transportation, biofuels will replace traditional fuels by 20% to 25% in 2036 compared with 7% in 2015, based on the National Energy Policy Commission 4/2558 on September 17, 2015 (Energy Policy and Planning Office, 2015b). **Still, petroleum in Thailand will dominate transportation fuels**. With a poor oil endowment, its oil imports account for 85% of the total oil supply as of 2015 (Department of Alternative Energy Development and Efficiency, 2016). **The vulnerable oil market influentially impacts economic activities as can be seen from several oil shocks that occurred in the past**. The high oil prices in 2005-2008, for example, were caused by low excess production capacity, higher cost of oil production, geopolitics in oil-producing nations, lower oil exports from exporting nations because of higher domestic oil demand, refining bottlenecks, high demand from emerging markets (especially China and India), and hedge funds (Koomsup, 2008). These external factors resulted in higher costs of transportation, switching to gas and biofuels, as well as requiring a serious re-thinking of emergency preparedness plans in Thailand. Expenses for energy of the average Thai household in 2008 increased by 23% to 1,710 Baht (51.25 dollars) compared with 1,387 Baht (36.57 dollars) in 2006 (National Statistical Office, 2015b) although the government stabilized retail petroleum product prices via oil funds and an excise tax.

It seems uninteresting to discuss high oil prices and oil shocks during a time when oil prices are low. However, the oil market fluctuates too much to overlook the possibility of future high prices. Oil shocks can happen again, severely impacting the Thai economy and society as long as the nation depends on oil imports, oil supply and demand are inflexible, and renewable energy is just a plan for the future. Preparedness for supply disruptions should be well established before the time of these possible disruptions in order to minimize the negative impacts. Policy responses to supply disruption typically involves 2 main approaches: **measures to increase oil supply and measures to decrease oil use**. The first one includes stock drawdowns and indigenous production surges while the second one includes demand restraint and fuel switching (International Energy Agency, 2014). The measures to increase oil supply are likely to be more attractive to the government because they do not require behavioral change by oil consumers. However, the potential for production surges is limited for Thailand as the country has only 3 years of proven oil reserves as of 2016 (Energy Policy and Planning Office, 2017), and its indigenous production is only about 10-20% of total production. Stock drawdowns are possible since the government requires oil traders to stock 25 days' worth of crude oil and petroleum products, based on National Energy Policy Commission 2/2558 on May 14, 2015 (Energy Policy and Planning Office, 2015b), but this measure alone is insufficient for an extended oil supply disruption, and a drawdown of Thailand's oil stock cannot calm down the world market. Fuel switching is a demand-side policy to provide additional fuels to supply the market, but the measure is limited in the short term for the transportation sector (IEA, 2014). An oil saving policy can relieve oil demand; however, this creates pressure on the government because the policy requires changes in lifestyle, limits oil consumption, and impacts economic activities (IEA, 2014). Hence, resistance to such a policy is likely to cause the government to lose its popularity. Consequently, the government tends not to implement mandatory oil saving policies and just utilizes them on a voluntary basis even though a saving policy can reduce oil dependence, improve terms of trade, and decrease greenhouse gas emission simultaneously.

Some energy background of Thailand is presented before moving to the next section. The indigenous production of fossil fuels cannot supply all the domestic consumption of the nation, so fossil fuel imports are needed. In 2015, more than half of the coal supply was imported. 74% of the total coal supply is used for electricity generation while 26% is used in the industrial sector. Natural gas is less dependent on import than other fossil fuels, as 72% of the total natural gas supply was produced domestically in 2015. Natural gas is mainly utilized for electricity generation, but it is also used in manufacturing and transportation. **For crude oil, indigenous production accounted for 10-20% of the total supply; as a result, the nation has to import about 80-90% to meet domestic needs**. Crude imports supply 50,802 million liters while domestic production accounts for 8,842 million liters. Most petroleum products are refined domestically and sufficiently supply domestic demand which was 58,369 million liters in 2015. Oil traders export some of the products except for liquefied petroleum gas (LPG) of which the nation has to import about 6,654 million liters. The LPG price has been subsidized for a long time. The 6 petroleum products mainly used in the country consist of LPG, gasoline and gasohol, diesel, jet fuel, kerosene, and fuel oil.

Transportation consumes about 68% of petroleum products while each of other sectors consume less than 15% (Department of Alternative Energy Development and Efficiency, 2016). The overview picture of energy flow of the country in 2015 can be seen in Appendix A. Recently, renewable energy sources such as biomass, biogas, hydro, solar, wind, etc. have played a more important role. For transportation, biofuels (ethanol and biodiesel) have been a key source of renewable energy in Thailand. Generally, diesel sold in gas stations is 5% by volume blended with palm oil under the requirement by Department of Energy Business while **gasoline consists of 95 RON gasoline** (premium unleaded gasoline without ethanol) **and gasohol blended with ethanol at different proportions**. Gasohol was introduced in the market in 2001, but its consumption did not become significant until 2006. In 2015, gasohol accounted for 94% of total gasoline consumption (Department of Alternative Energy Development and Efficiency, 2016). Gasohol sold in the market consists of 4 grades: gasohol 95 E10 (10% of ethanol by volume), gasohol 91 E10 (10% of ethanol by volume), gasohol E20 (20% of ethanol by volume), and gasohol E85 (85% of ethanol by volume). Base gasoline (without ethanol blended) remains the main component of gasohol except for gasohol E85 which in 2015 accounted for less than 4% of total gasoline consumption (Department of Alternative Energy Development and Efficiency, 2016). **Other alternative fuels used currently in road transportation are LPG and natural gas for vehicles (NGV)**.

Unsustainable energy in the modern world exists as people rely on cutting-edge science, technologies, and businesses. Higher consumption creates better value, but increases in energy uses cause tremendous ecological and environmental impacts.

Furthermore, many transformations to sustainability in modern cities do not actually change unsustainable ways of life as they just intend to transform to serve their technology and economies under technicism and capitalism (Byrne, Toly & Glover, 2006). Meanwhile, the world's energy security has not yet improved although several nations have made many efforts to increase energy security since the 1970s. Policymakers should consider the threats from availability, affordability, efficiency, and stewardship (Sovacool, 2012). Another study points out that reaching sustainability in transportation requires technical improvement of vehicles (such as cleaner conventional vehicle technologies, alternative vehicle fuels and engines, etc.), behavioral changes (such as incentive mechanisms for employers to encourage their employees to commute using greener methods, raise awareness of sustainable transportation, etc.), and others drivers of transformation (such as environmental drivers, health issues, traffic congestion, and global economic drivers) (Warren, 2007).

Thailand desires **energy sustainability** as well. In Thailand, public transportation should be the primary consumer of future transportation energy. In addition, public transportation should be affordable, reliable, and run by electricity generated by 100% renewable energy. Thus, the country will be independent of imported petroleum and generate zero emissions, and people will not be dependent on private cars. Although electric cars are more efficient than conventional gasoline cars and produce zero emission, public transportation with good service and infrastructure utilizes less natural resources per passenger than electric private cars do. However, before Thailand reaches that point of transformation, the country is still vulnerable to petroleum markets; hence, it is important not to overlook the improvement of the country's oil emergency response plan. Additionally, the plan should be more sustainable and should take into account the long-term plan of high penetration of renewable energy. Like other developing countries, Thailand faces several urgent problems, and when a supply disruption occurs, short-term solutions with shortsighted means are likely to be used. **Making the short-term solutions (or emergency response plan) to be more sustainable and foresighted is thus an important part of the transition to the future achievement of the long-term goal**. Although moving to a higher penetration of renewable energy is the final goal, **an oil saving policy is another option that can be used no matter what kinds of fuels the country consumes**. This study focuses on a fuel saving policy for Thailand. Since oil is dominant in transportation at the present and will be for the next 20 years, and gasoline is consumed by most people, **this study pays attention to an oil saving policy focusing on gasoline**. However, this policy can be applied to biofuels, and other types of renewable energy, making it useful for the future transition as well.

1.2 The Focus of the Study

The future energy for Thailand addressed in section 1.1 requires two components: both an oil saving policy and making a switch to renewable energy. This study only focuses on the first component which can be used as a complement to the second one. The study specifically pays attention to demand reduction policies which can be immediately utilized during crises rather than depending on fuel-efficient vehicles which will require time and budget accommodations in order for consumers to switch. Improving oil saving measures for Thailand is thus the key of the current study.

A crisis in this paper is defined from the viewpoint of oil importing nations as one of 3 basic events: a physical shortfall in the supply, a rapid and severe increase of oil prices, or the combination of a physical shortage and a price increase. Some researchers do not consider the rapid and severe increase in oil prices alone as a crisis because supply is still available. However, an oil price increase can lead to unstable situations that ultimately affect individuals and groups, especially the poor who cannot afford a higher cost for energy. The high oil prices in 2005 and 2008 in the world oil market can be categorized as crises in this paper even though there were no physical shortages in Thailand. This is because the rapid and severe increase in the world oil prices caused higher import value and higher domestic oil prices which affected people's livelihood. Government intervention is needed when there is a limited ability for oil supply and demand to adjust in the short-term. An oil crisis can originate from either supply disruption or demand change because the bottleneck can make the market imbalanced. In other words, a crisis is defined more broadly than just a supply disruption. The market tends to have more time to adjust to a demand change, but in the case of supply disruption, consumers might not be able to deal with the abrupt change and their responses might be too small and too slow.

Because transportation is dominated by oil, and oil disruption and high oil prices can happen anytime in the future, developing policies in response to oil crises are vital for an oil-importing nation like Thailand. While an oil saving policy offers less dependence on oil and lower emissions, policymakers and consumers tend to find adhering to such a policy difficult, as it requires behavioral adjustments which some consumers might reject.

However, if the negative impacts from saving measures such as limited mobility, less convenient transportation, an increase of commute times, etc. are reduced (or eliminated), the saving measures can then be extensively and willingly applied.

This study is divided into 3 parts: an examination of oil crises and oil saving policies, an empirical study of gasoline demand in Thailand, and recommended oil saving policies for Thailand.

The first part, **oil crises and oil saving policies**, examines policies and consumer behavior during oil crises and normal circumstances. Because an oil crisis can negatively impact the economy and society, preparation to respond to the crisis is necessary. The study briefly discusses the ways to increase the supply and ways to reduce demand in general and then pays attention to oil saving measures, especially the measures and guidelines employed in previous crises in other countries since studies about oil saving in Thailand are limited. The measures include pricing measures (PM), public transit enhancement (PT), carpooling (CP), telecommuting (TC), compressed workweek (CW), rationing (RT), driving restriction (DR), non-motorized modes (NM), and eco-driving (ED). The saving measures during normal circumstance are reviewed as well because there is limited evidence of the measures used during a crisis, and the same measures used during normal circumstances can be applied to a crisis. The lesson learned provides valuable evidence for the analysis for Thailand in the third part of the study. To analyze and understand these saving measures, an E4 framework (energy, economy, equity, and environment), an energy contingency plan, and a human ecosystem model are used. In this part, five research questions are involved: What emergency response policies can bring the country to achieve the E4 goals? What are saving measures used during crises in the past? Are those measures effective? What are the challenges of implementing the saving measures? Can the saving measures generate less negative impacts? Methodology and results are presented in sections 3.1 and 4.1, respectively.

The second part moves from other countries to Thailand in a quantitative view. **The empirical study of gasoline demand in Thailand** tries to understand the nature of gasoline demand in Thailand and major influences on the demand. The study should examine the oil market in terms of both supply and demand. As an oil-importing nation with limited indigenous reserves, it is impossible for Thailand to substantially increase its indigenous production to the point that it can supply most of its domestic demand or slow the oil prices down. Consequently, oil demand is emphasized in the paper. The study pays attention to gasoline prices and other demand shifters such as income, prices of substitute fuels, macroeconomic factors and other factors. In this part, the research questions include: How does gasoline demand respond to gasoline price changes? How do other important factors affect gasoline demand in Thailand? Do oil shocks play a role in gasoline consumption? The methodology and results are found in sections 3.2 and 4.2, respectively.

The third part, **oil saving policies for Thailand,** identifies those policies and makes recommendations for Thailand by applying the information gained from the first and the second parts to the context of Thailand. Other important evidence about Thailand comes from an online discussion forum, government documents, and articles. The research questions are: What differences and similarities regarding the saving measures can be found between the evidence from other nations and the evidence found in the context of Thailand? What are the recommendations for Thailand? The methodology and results are found in sections 3.3 and 4.3, respectively.

To sum up, this study attempts to examine the policies used to respond an oil crisis. This study focuses on an oil saving policy due to the fact that it leads to less dependence on oil compared with the measures to increase supplies, although some policymakers avoid implementation of a saving policy. An oil saving policy also carries the benefit that it can be used along with a fuel switching policy. Lessons learned from other countries and guidelines by energy policy experts are addressed. After that, the study focuses on gasoline demand in Thailand, especially the correlation between gasoline demand and gasoline price. Finally, the study tries to identify what policymakers should do to increase the efficiency of each oil saving measure for Thailand.

1.3 Significance

An oil saving policy can be used to cope with an oil crisis and its impact on Thai economy and society. The study contributes to **Thai transportation** by increasing the effectiveness and smoothness of the saving measure implementation.

The study benefits **policymakers** as they can understand how gasoline consumers in Thailand respond to price changes. Also, it assists policymakers to utilize an oil saving policy as a primary measure with minimal resistance and negative impacts. Unlike a supply-side policy, being less reliant on oil is an important option for the nation, especially during a crisis when renewable energy has not yet dominated transportation. In the future when renewable energy penetrates more in transportation, the oil saving policy can still be applied and also offers an additional contribution.

Gasoline consumers may be affected by the saving measures as they will require behavioral changes. The study examines the challenges and presents recommendations which policymakers should take into account in order to minimize undesirable effects.

The study focuses on the saving measures implemented during a crisis. However, some of the measures can be used in **the longer term** and will help move the nation away from oil permanently. Moreover, the findings in the study can be applied for biofuel, the share of which Thailand's AEDP 2015 aims to increase in transportation. Additionally, saving measures can also contribute to **the environment**. Some of the saving measures can be applied to zero-emission vehicles. In addition, the measures include reduced dependence on private cars. This means less dependence on natural resources as well as manufactured resources such as the vehicles themselves, batteries, and other components.

Although Thailand is employed here as a case study, this study can help **other oil-importing developing nations** to cope with an oil crisis and to develop some of those measures for longer-term policies to reduce both oil dependence and emissions.

Chapter 2

CONCEPTUAL FRAMEWORK AND RELATED LITERATURE

2.1 Fundamental Concepts of Supply and Demand

2.1.1 Law of Supply

The price of a commodity is a major factor determining supply. Firms or producers are capable and willing to manufacture and sell more of a good if the price increases. This can be simply explained: when the price increases, producers have the ability and desire to expand their production as they can hire more workers. This phenomenon might also attract new firms to enter the market. Nevertheless, for some goods, firms face capacity constraints as they need to expand facilities, hire professionals, etc., so the quantity of the good supplied might not quickly respond to sharply raised prices of the good. Apart from price, there are other important variables that influence the quantity supplied, for example, wages, costs of raw materials, etc. (Pindyck & Rubinfeld, 2012).

High oil prices attract more oil producers to step into the market and stimulate technology development to drill oil in deep offshore waters and other use other unconventional methods to recover oil, but these might take more than a year to adjust. Oil reserves are unevenly distributed and vulnerable to geopolitical risks; moreover, to develop new projects, the producers may encounter capital intensiveness, asset specificity, long-life assets, long gestation periods, and other risks such as finding dry holes, contractual risks, commercial risks, and so forth (Bhattacharyya, 2011). For the case of Thailand specifically, an increase in oil price attracts domestic oil producers to raise their production. However, domestic producers not only need the time, budget, and skill to expand their capacity, but domestic production is also limited as mentioned in Chapter 1; therefore, an increase in the quantity supplied in the short term is very limited. In other words, the short-term oil supply is inelastic. Supply disruptions can thus lead either to shortages or rapid increases in oil prices. Moreover, several nations consider their oil supply as part of their national security; hence, the quantity supplied and supply disruption are major issues for them. Common causes of supply disruptions include unforeseen technical problems, the weather, civil unrest (IEA, 2015), and terrorist attacks. Examples of these events are the oil embargo in 1973, the oil strike in Venezuela and the Iraq war in 2003, Hurricanes Katrina and Rita in 2005 in the Gulf of Mexico, and the civil war in Libya in 2011.

2.1.2 Law of Demand

In *Principles of Economics*, Alfred Marshall views human wants and desires that are infinite. People desire larger and better quantities of a commodity. Demand is closely correlated with price. The general law of demand is that an increase (decrease) in price leads to a decline (increase) in the amount demanded (Marshall, 1920). Demand should be expressed with the reference of its price during a given time and under given conditions (Marshall, 1920). This assumption is important because the demand for a particular commodity can change under a new set of customs, adjustments in the price of a rival commodity, or in light of a new invention (Marshall, 1920). Although the price of a particular commodity is an important factor, it is not the only factor determining the quantity of a good which consumers want to purchase. Other factors such as income, substitute goods, complementary goods, weather (Pindyck & Rubinfeld, 2012), tastes, habits, fashion, population, etc. can also influence demand by shifting the demand curve.

To capture how consumers respond to price changes, one needs to understand price elasticity of demand which represents "percentage change in quantity demanded of a good resulting from a 1-percent increase in its price" (Pindyck & Rubinfeld, 2012, p. 33). Income elasticity of demand, cross-price elasticity of demand, and other variables including elasticities of supply can also apply to this concept. In the case of gasoline demand, factors influencing demand include the price of gasoline, the price of diesel, the price of LPG, the price of NGV, income, number of vehicles, population, and so on. Price elasticity is expected to be negative while income elasticity and other fuel-price elasticities are expected to be positive. The short run usually refers to a one-year period or less whereas long run refers to enough time that consumers can fully adjust to price change. In the case of gasoline, a rapid increase in price causes drivers to drive less and consume less gasoline. However, consumers have limited ability to change to smaller and more fuel-efficient cars or stop commuting to work; as a result, gasoline consumption decreases slowly in the short run (Pindyck & Rubinfeld, 2012). During an oil crisis, consumers thus are likely to have limited ability to adjust their consumption.

2.1.3 Equilibrium and Government Intervention

Equilibrium is the point that the demand curve and supply curve intersect; in other words, the equilibrium price is the level of price "that equates the quantity supplied to the quantity demanded" (Pindyck & Rubinfeld, 2012, p. 25). In a free market, price changes clear out excess demand or excess supply. Surplus and shortage can happen in the market. From the consumers' point of view (or oil-consuming nations' point of view), a shortage is undesirable. The situation will push the price to a higher level. Sometimes governments intervene in the market by subsidization or taxation which distorts the market.

In the case of oil crises, governments can implement supply-side and demand-side policies to cope with the problems. A production surge is a supply-side policy that can be employed, if available. Thailand can implement both policies at a limited level as the indigenous resource is small, and the private oil stock lasts for only 25 days. A demand-side policy is thus an important choice. Switching to renewable energy or other fuels is an option. Biofuels, NGV, and LPG are used in transportation in Thailand. Gasohol blended with ethanol is subsidized as a renewable energy; the subsidy of NGV price is in the process of being phased out whereas the LPG price is now partially floated after a long time of heavy subsidization. Moving to other types of energy introduces another problem as people are addicted to new cheap subsidized energy. Oil saving is another choice during a crisis. Generally, the high oil price brings the quantity of demand down under market mechanism. However, demand response to petroleum prices is slow and insignificant because of their inelastic demand. Thus, governments might intervene via oil saving measures which this study focuses on. Saving measures can increase the elasticity of demand and will reduce the loss of consumer surplus (IEA, 2005b; Noland, Cowart & Fulton, 2006).

2.2 Sustainability and Energy Contingency Plan

2.2.1 E4 Perspectives (Energy, Economy, Equity, and Environment)

Moving toward sustainable development, energy planning to respond to oil crises should take E4 perspectives into account. Thomas B. Johansson points out the importance of social development and poverty alleviation, economic growth, and protecting the environment. However, some of these objectives have attracted much less attention than others (Johansson, 2005). During the period of an undersupplied market, the problem may be solved by deep water oil drilling, hydraulic fracturing and so forth. However, these methods might result in serious environmental issues (Peters & Zittel, 2014) like the Deepwater Horizon disaster in 2010, or the extensive use of water, propping agents and chemical additives for extracting oil from tight reservoirs (Peters & Zittel, 2014). To deal with impacts of high oil prices on low-income households, some governments offer temporary reactive financial assistance which generates short-term additional income to those households. However, these policies do not solve or at least address the root cause of the problem (Chester, 2014). Several governments in developing countries which are trapped in these paths find it difficult to overcome consumer addiction to fossil fuels.

Taking into consideration the E4 perspectives of energy as it involves economy, equity, and environment can provide a more sustainable future. The equity aspect should involve collaboration with energy services in order to meet development goals; to improve (modern) energy accessibility; to provide reliable, safe, and affordable energy (Johansson, 2005), and to reduce energy poverty. The economy aspect involves the attempt to ensure a secure energy supply to serve the economy and prevent the risk of energy supply disruptions which can damage the economy. The environment aspect suggests minimizing pollution, conserving natural resources, and minimizing climate change. The E4 framework should be considered for making both long-term and short-term energy policies including the policies dealing with an oil crisis. A short-term policy with well-balanced E4 perspectives can turn the short-term transformation process into a long-term transformation.

2.2.2 Human Ecosystem Model

The human ecosystem model is adapted by Guerin in 1992 from a study by Bubolz and his team in 1979 and by Morrison in 1974. The model explains interactions among "human organisms (HO), the natural environment (NE), the social environment (SE), and the designed environment (DE) in the human ecosystem" (Guerin, Yust & Coopet, 2000, p. 56). The idea behind the model is that there is interdependence between people and the other parts of the system and humans cannot be completely isolated from the environments, and the interactions affect energy consumption. The model is used to identify how the interactions among the 4 components impact household energy consumption (Guerin et al, 2000).

Each environment is defined as follows:

"Attributes of the NE related to energy include climate which can be measured in heating and cooling degree days" (Guerin et al., 2000, p. 56).

"Attributes of the HO include the number of people in a house, age of the occupants, and gender." (Guerin et al., 2000, p. 56)

"Attributes of the SE include conservation strategies, sense of comfort, cultural norms, laws, tasks, and activities." (Guerin et al., 2000, p. 56)

"Attributes of the DE related to energy include the year the house is built, the number of appliances, the size of the house, and clothing worn by the occupants." (Guerin et al., 2000, p. 56-57)

Considering the 4 components of the human ecosystem system model helps understand and classify factors determining energy consumption and conservation. Unlike the cited study by Guerin et al., which deals with household energy conservation, this study uses the model for gasoline conservation in transportation. For example, the public transportation used in an area is limited because of the poorly designed environment such as a poor public transportation network and badly maintained sidewalks. Moreover, the social environment can discourage the use of public transportation since society has the attitude that bus riders are poor. Looking at the situation systematically through the model help analyze the strengths that can be built upon and the challenges Thailand faces in implementing oil saving measures.

2.2.3 Energy Contingency Plan

Davis reviews several energy contingency plans of states and cities in the U.S. prepared in response to energy shortages after the 1970s crises on the basis of gathering availability of data. His objectives were to cut down energy use through modal changes to a more energy efficient transportation, to offer an option to maintain mobility, to provide public information, and to reduce the degree of supply disruptions (Davis, 1983). Based on those energy contingency plans, several criteria were gathered and transformed to 8 performance measures for evaluating each implementation strategy (Davis, 1983). An energy contingency plan should not only offer implementation strategies, but also discuss how it could perform regarding the performance measures mentioned above (Davis, 1983).

The performance measures include:

- "Pre-implementation activities
- Contribution to maintaining mobility
- Demand restraint potential and implementation time
- Public acceptability and information component plan updates
- Funding
- Equity considerations
- Monitoring system, triggering mechanism, and institutional legal barriers including securing agreements and supports
- Potential effectiveness and impact" (Davis, 1983, p. 93)

2.3 Related Literature

2.3.1 Oil Crises and Oil Saving Policies

2.3.1.1 Oil Crises and Response Measures

Oil supply disruptions happen and have impacted the world energy market, especially the oil market today with the development of spot and futures markets. Physical shortages generally occur together with sudden high oil prices, but high oil prices do not necessarily come with physical shortages. Both oil shortages and high oil prices negatively impact consumers. The International Energy Agency (IEA) views the Suez Canal Crisis in 1956-1957 as the first important oil disruption. Because of the conflict, about half of the canal's transit of oil was blocked. The oil crises in the 1970s and the 1980s are major oil supply disruptions that led oil consuming nations to reform their energy policies. Besides political unrest in the oil-producing countries, natural disasters also substantially impact oil supply (IEA, 2014).

As mentioned earlier, several measures can be used during a crisis. The IEA categorizes the measures into 4 types: production surges, stock drawdowns, fuel switching, and demand restraint (IEA, 2014). The paper briefly discusses the first 3 measures but focuses more on demand restraint.

Production Surges

Not many pieces of literature study surge production during a crisis. However, the IEA considers an increase in oil production as a response measure for a crisis. The measure can raise "the availability of oil supplies" (IEA, 2014, p. 24) which come from indigenous sources. However, the measure has limitations because the amount of unused production capacity that a country has available may be low, and maintaining appropriate "oilfield practices" is needed (IEA, 2014, p. 24). The IEA finds that oil producers normally "maximize their productions rates" rather than "maintain spare production capacity" (IEA, 2014, p. 42). Governments might have to "relax regulations" such as "oil-well safety condition" for a short time in order to implement this measure (IEA, 2014, p. 42).

Stock Drawdowns

Another supply-side policy is a stock drawdown. The IEA claims that stock drawdown "is the most powerful mechanism available to IEA member countries" (IEA, 2014, p. 12) by providing "additional oil" from emergency stocks to an oil market during supply disruptions (IEA, 2014, p. 22). The IEA requires its member nations to maintain oil stock level "90 days of last year's net imports" (IEA, 2014, p. 22). The obligation to maintain the stock was formulated in 1974 in order to create "common emergency self-sufficiency" (IEA, 2014, p. 29) in oil supplies after the 1973 oil crisis. Initially, the oil supply disruptions that generated "a loss of 7% or more of normal oil supply" in total or individual IEA member countries could trigger a cooperative action of stock drawdowns (IEA, 2014, p. 39). However, today the measure is adjusted to be more flexible and faster by having the IEA Governing Board assess and inform the activation of a significant disruption. After the member countries are informed by the IEA executive director for a suggested volume of oil to the market, governments will make a decision regarding their contribution. These processes take 2-7 days to release the oil stocks (IEA, 2014). So far emergency stocks have been withdrawn 3 times. The first time was in response to 1990-1991 oil supply disruption caused by the Iraqi invasion of Kuwait with the loss of 4.3 million barrels per day (IEA, 2014). Only 1.3-1.4 million barrels per day of oil were fuel conservation; the rest came from fuel switching and surge production (IEA, 2014). During the supply disruption in 2005 from Hurricane Katrina, the IEA agrees to inject 60 million barrels of oil to the market for a month and initial response of withdrawal was 2.1 million barrels per day: 94% from stock drawdowns, 3% from fuel savings, and 3% from surge production (IEA, 2005a). The latest stock drawdown was in 2011 to increase the supply caused by the Libyan disruption. The IEA decided to offer 2 million barrels of oil per day for 30 days into the market (IEA, 2011).

Several IEA member countries are European Union (EU) member countries (IEA, 2014), and under the EU's 2009 oil stock directive it is mandatory to have emergency reserves of crude and/or products equal "to 90 days of average daily net imports or 61 days of average daily inland consumption, whichever of the 2 quantities is greater" (Council Directive 2009/119/EC, 2009, p. 13). The EU directive also requires at least one-third of the mandatory stock to be met with petroleum product stocks (European Union, 2009). Thus, the EU net exporting nations which are not required to hold emergency stock by the IEA are required to do so by the EU directive (IEA, 2014).

The initial criteria of a 7% reduction of physical supply triggering the stock drawdown in the 1970s. Sweden experienced more than a 7% reduction in imports during the 1979 crisis, but the IEA Governing Board did not decide to use emergency stocks because the reduction was under 7% with seasonal adjustment and the improving situation (Emerson, 2006). To decide whether to release oil stocks or not is controversial owing to the concern of a possible worse circumstance. "The precise balance and timing" between the stock drawdown and the market forces are hard to identify (Emerson, 2006, p. 3385). In the 1970s the world oil market involved a few players, but currently there are several players in the market with spot and future prices. Several analysts claim that the oil price (not the volume) should be what triggers a crisis as the price mechanism would re-balance the market (Emerson, 2006). This is because the market responds by reallocating supply and demand for a new balance.

Fuel Switching

This measure provides more supplies available in the market after changing to other types of fuels during an oil crisis. The experience from the IEA shows that the potential of a fuel switching policy during a crisis plays a less important role because electricity generation in several countries have already switched from oil to gas and nuclear since the 1970s. Currently, fuel switching is more possible in the transportation sector and petrochemical industry where oil uses are still considerable, but the potential to switch to other fuels during a short-period crisis is insignificant (IEA, 2014). The evidence from the three IEA emergency response actions mentioned above explains that only the first IEA coordinated action in 1991 implemented fuel switching measures, and it accounted for only 2.7% of the total additional oil. Fuel switching did not contribute to the last two actions (IEA, 2014).

Demand Restraint

The policy aims to decrease oil use to respond to “an under-supplied market” (IEA, 2014, p. 24). The measures range from a very “light-handed” or “voluntary” basis to very “heavy-handed” measures or prohibitive basis (IEA, 2014, p. 42). More details of each measure are discussed in the paper.

2.3.1.2 Saving Measures Experiences and Guidelines

During the Suez Crisis in 1956-1957, fuel rationing was used in Britain, but at that time there were only 5 million vehicles while by 1967 there were 10 million vehicles.

Fuel rationing during the 1967 crisis was proposed but not imposed because of the increasing number of vehicles and its complication (Thorpe, 2007). The article narratively explains the problems and how the government prepared in 1967 (Thorpe, 2007).

Lee-Gosselin studies demand reduction policies in the 1970s and 1980s in the U.S. and Canada for the reduction in energy consumption and carbon emission by reviewing several pieces of literature (Lee-Gosselin, 2010) For the U.S., speed limit was enforced in 1973. The Energy Policy and Conservation Act was signed in 1975, and the strategic petroleum reserve was built. The Standby Rationing Plan was established to distribute coupons for licensed vehicles instead of licensed drivers. During the 1979 crisis, state governments had more important roles involving oil saving policies as different regions are unique and have particular issues, but the plans were cancelled in the 1980s and market mechanisms are used before the prohibitive measures; however, the U.S. set up measures in accordance with the International Energy Agency (IEA) (Lee-Gosselin, 2010). Unlike the U.S., Canada agrees to intervene to reduce consumption at an early stage of a crisis and ration when it is necessary. Canada is likely to use voluntary saving meausres at an early stage “to lower the chance” of shortage (Lee-Gosselin, 2010, p. 170) while the U.S. looks to its strategic petroleum reserve along with coupon rationing if the shock rapidly becomes severe (Lee-Gosselin, 2010).

A study by Peck and Doering III is conducted by employing the information of the 1973-1974 crisis to examine the behavior of the preferences of energy consuming households and their response to changed prices to assess the effectiveness of the conservation policy in voluntary adjustment of heating fuel consumption habits in Indiana (Peck & Doering III, 1976). They examine the demand and price data of LPG and natural gas, heating degree days, and fuel-use efficiencies of LPG and natural gas. They finally conclude that national effort alone to change fuel consumption is not effective. To make a substantial move in addition to the fuel saving policy, price signal is very important (Peck & Doering III, 1976).

In contrast, Reiss and White find a responsive evidence to an energy saving program during the California's electricity crisis in 2000-2001. The study utilizes data and utility bills before the crisis (1997-1999), during the crisis (1999-2000), and during the conservation campaign (2000-2001) in San Diego to examine whether "public appeals for voluntary conservation" to cut demand work or not (Reiss & White, 2008, p. 636), since price mechanisms might be interrupted as politician tended to keep energy prices low during the crisis (Reiss & White, 2008). During the very first period of the crisis, consumption was stable since consumers were unaware of price hikes until they received their bill a month after. However, the state government introduced an intensive campaign to reduce consumption by providing information and education through several channels (Reiss & White, 2008). In spite of having no financial incentives from the price cap policy since September 2000, Californian households sharply "responded to the media attentions and public appeals for the conservation" (Reiss & White, 2008, p. 658).

Noland et al. comprehensively examine various saving measures for transportation during an emergency. They analyze the measures based on data availability, literature reviewed, and several assumptions for the IEA countries. The transportation policies they analyze include 1) pricing measures, 2) increasing transit ridership, 3) enhancing carpooling, 4) enhancing telecommuting, 5) promoting compressed workweeks, 6) enforcing odd/even driving restrictions, 7) reducing speed limits on roads, and 8) adjusting tire pressures (Noland et al., 2006). The authors explain the different potentials of the measures when they are implemented in different regions. For example, carpooling tends to offers great opportunity for U.S. drivers whereas walking and riding public transit are useful options for European commuters. They also discuss the different consequences between normal circumstances and crisis because during a crisis people might not be able to afford fuels at high and altruistic behavior might help save energy (Noland et al., 2006).

The most informative and comprehensive research on oil saving policies was created by the IEA in 2006, especially for an emergency. IEA uses existing estimates from different sources of literature for its analysis for the member countries in 4 regions. However, severe lack of information about crises causes the paper to rely on “longer-term effects and analyses” (IEA, 2005b, p. 131). In order to focus on emergency, the study utilizes “expert judgment” to estimate behavior and responses (IEA, 2005b, p. 131). The IEA categorizes oil saving measures by their degree of effect. The IEA also performs a cost-effective analysis per barrel of oil saved on those measures and concludes that large and small program carpooling is very low cost (IEA, 2005b). Similar to the previous literature by Noland et al. (2006), IEA investigate those saving measures in details.

2.3.1.3 Behavior and Attitude during a Crisis and during Normal Circumstances

Behavior and Attitude during a Crisis

Lee-Gosselin uses gaming-simulation techniques with quota sampling to investigate behavioral changes during a shortage. His survey in Canada includes the households that have vehicles in 1984 and 1988 (Lee-Gosselin, 2010). The simulation game is separated into 3 stages. The first stage involves how the respondents save fuel during normal circumstances. The second stage asks respondents to imagine how they would change their behavior for conservation on a voluntary basis while the third stage asks them how they would respond to a rationing scheme. His study found that people were willing to cooperate with government. While most people surveyed understood how to save fuel at considerable levels, their willingness to do so depended on their perception of the “genuineness” of the shortage (Lee-Gosselin, 2010, p. 171).

More recent surveys involve the U.K. fuel tax protests of September 2000 in response to rising prices of oil. A survey by Lyons and Chatterjee was conducted right after the crisis ended to capture all details “before memories faded” (Lyons & Chatterjee, 2002, p. 125). This survey, as a result, gains the advantages of acquiring actual behaviors in response to real circumstances rather than imagined responses to a hypothetical situation. The questionnaire was designed to elicit car users’ normal travel behavior and how the crisis affected them. The questionnaire comprises 8 sections to capture behavioral changes during the crisis. Several open-ended questions are employed in the mail-back questionnaire, as there was no time to pilot it before the unexpected crisis. The authors distributed more than 10,000 questionnaires in 5 areas and also created Internet surveys. The team had to categorize and code the responses. The authors realize that only particular types of people and ones who have “strong opinions” returned the questionnaires even though the questionnaires were distributed in different areas (Lyons & Chatterjee, 2002, p. 129). The results show that about 75% of car users changed their travel behavior during the crisis (Lyons & Chatterjee, 2002). The authors also point out the barriers which might have made car users not continue their changes. Thus, “sustained policy initiatives” and “policy actions” for both the short term and long term are necessary (Lyons & Chatterjee, 2002, p. 156).

Noland, Polak, Bell, and Thorpe conduct another survey on the 2000 British fuel shortage. The protest and hoarding by consumers resulted in a temporary gasoline supply disruption. Their survey is done two months after the crisis ended so they could elicit information from the fresh memory of respondents; moreover, the survey asked questions about respondents facing future oil supply disruptions. The data was collected from 1,001 randomly selected respondents via telephone survey in London, the Southeastern region, and the Northeastern region (Noland, Polak, Bell & Thorpe, 2003). Their survey covered “demographic data”, “normal travel activity”, “actual responses” to the crisis in 2000, and “stated responses” to a crisis in the future (Noland et al., 2003, p. 465). The authors also use an “ordered probit model” to find out how a future shortage will impact travel for eight types of journeys (Noland et at., 2003, p.466). The researchers find that reducing vehicle use, increasing public transport use, and promoting non-motorized modes of transport are “difficult” owing to the existing levels of “car dependency”, but the improvement of “an integrated transport system” can make the policies successful while “increases in fuel prices” might lead to another protest (Noland et al., 2003, p. 478).

Another study conducted prior to and during the U.K. fuel crisis in 2000 is by Beatty, Meadows and White. The purpose is to find out changes in “drivers’ willingness” to drive less before and during the crisis (Beatty, Meadows & White, 2002, p. 184). The questionnaires were distributed in April and September in 2000. The 855 respondents from Staffordshire University allocated themselves to one of 5 stages which were “pre-contemplation (not yet thinking to reduce their car use), contemplation, preparation, action, and maintenance (reduction in car use has been done and the respondent planned to keep it that way)” (Beatty et al., 2002, p. 185). The survey done before the crisis shows that 41%, 7%, 22%, 7%, and 23% are in the stages of pre-contemplation, contemplation, preparation, action, and maintenance, respectively. The authors conducted the second survey on those who allocated themselves into three of the stages: the pre-contemplation, preparation, and maintenance stages. The results show that 41.1% of the respondents mentioned that their traveling plans were affected by the fuel shortage. 28.8% of pre-contemplation people, 49.0% of preparation people, and 40.3% of maintenance people (classified before the crisis) mentioned the effects of traveling plans (Beatty et al., 2002). They mentioned concern over “cancelled or altered plans, using alternative forms of transport and finding alternatives to having to travel” (Beatty et al., 2002, p. 190). The study finds that some respondents used trip reduction strategies such as “more use of the telephone, working from home, using video conferencing, and staying overnight” (Beatty et al., 2002, p. 191. The authors employ “Kruskal-Wallis ANOVA” to test whether the “degree of stage movement is statistically significant” (Beatty et al., 2002, p. 196). Also, they use the “Mann Whitney U test” to examine where “the differences between stages lay” (Beatty et al., 2002, p. 197). They find different directions of movement. About 72% of the respondents categorized as pre-contemplation in the first survey stayed at the same stage in the second survey, but the others moved up to other stages. About 25% of the respondents categorized as preparation in the first survey stayed at the same stage, but about 28% moved down to pre-contemplation and contemplation stage, while the rest moved up to action and maintenance stages. About 58% of the respondents categorized as maintenance in the first survey stayed at the same stage, but the rest moved down a stage. The authors point out that the move to an earlier stage can be the result of the crisis that made some drivers realize the difficulties of using alternative methods of traveling. Moreover, miles driven can be the important factor classifying stages of each driver (Beatty et al., 2002). To move the pre-contemplation group to a later stage, rewards can be a tool as the study found that those of pre-contemplation group used “reinforcement management” to encourage their car independence (Beatty et al., 2002, p. 202).

Saving measures are identified in several studies mentioned earlier; however, Shahabuddin and Chang conduct a survey and do an OLS analysis. With 1,665 samples in 1974, they find rich and young people and people who drive a lot are likely to prefer price rise to the prohibitive measure like fuel rationing when they encounter an energy shortage. People residing in a place with poor access to public transit, Caucasian and males prefer higher fuel prices to the prohibitive measure. The study concludes that governments should allow prices to elevate in order to slow down gasoline consumption, but should subsidize poor people (and other groups as necessary) since they have less capability to deal with the free market (Shahabuddin & Chang, 1978).

Behavior and Attitude during Normal Circumstances

Several pieces of literature pay attention to energy conservation in general rather than during a crisis. Lutzenhiser proposes a cultural model or household lifestyles in order to predict energy consumption accurately in the household, but he also explains other approaches (Lutzenhiser, 1992). Engineering aspects focus on the physical and human action, but normally fail to consider other aspects (Lutzenhiser, 1992). “An economic model or a model of price and the rational consumer” (Lutzenhiser, 1992, p. 51) contributes how important factors correlate with energy consumption; however, the correlation might change as “the choices of technology and behavior” (Lutzenhiser, 1992, p. 51) in the future might differ those in the past and non-economic factors are also important. “Psychological models or a model of how an individual thinks” (Lutzenhiser, 1992, p. 51) pay attention on “individuals' perceptions, valuation processes, risk assessments, cognitive operations, personality structures, attitude systems, and norm internalization” (Lutzenhiser, 1992, p. 51). “Models of social consumers” focus on the behavior of individuals’ interactions and other demographic factors. However, energy attitudes and social factors could not closely explain energy saving intention and consumption. Thus, a cultural model is proposed in his study, and demographic variables, exploratory researches and surveys are important for the model (Lutzenhiser, 1992).

A study by Costanzo, Archer, Aronson, and Pettigrew also points out the shortcomings of the economic perspective. They find that many conservation campaigns are information campaigns which rely on the “attitude-change model and the rational-economic model” (Costanzo, Archer, Aronson & Pettigrew, 1986, p. 521), which are unclear and misestimate “the complexity of human behavior”, even though they are useful to some degree (Costanzo et al., 1986, p. 521). Thus, “social-psychological aspects” or “behavioral and social research” should be taken into account for energy conservation campaigns (Costanzo et al., 1986, p. 521). The paper draws attention to “psychological factors concerning how information is processed by individual decision makers and to positional factors concerning characteristics of the decision makers' situations that support or constrain action” (Costanzo et al., 1986, p. 522).

Focusing on attitudes and acceptance, Marvin E. Olsen employed a mail questionnaire in Washington during spring 1981 to examine 6 strategies to enhance energy savings (Olsen, 1983). Appropriate strategies must offer both effectiveness and also desirability, but the study focuses on the latter one. The author finds that money “incentives”, “community programs, and efficiency standards” are more preferred consecutively while price increases, “consumption limits” and “land use changes” are less preferred (Olsen, 1983, p. 195), but the more serious people perceive the crisis to be, the more supportive they become of the saving measures (Olsen, 1983).

2.3.2 Empirical Study of Gasoline Demand

Various studies examine gasoline demand with econometric techniques. Some of them look at several nations while some of them focus on one country. The econometric models range from simple models to more complicated ones, and the factors in the models range from a few explanatory factors to several.

2.3.2.1 Survey of Gasoline Demand and Meta-analysis

Meta-analysis and survey of gasoline demand have been done by several researchers. Dahl and Sterner survey several pieces of literature for elasticity gasoline consumption. Based on studies conducted in 1966-1988 in several places, they categorize the models into several groups including a simple model (with the 2 main factors: price of gasoline and income), a lagged endogenous model (with the 2 main factors and gasoline demand in the previous period), a stock of vehicles model (with the 2 main factors and stock of vehicles), a size and characteristics of automobiles model (with a proxy for efficiency or others with the 2 main factors and stock of vehicles), other lagged models (with the previous lag of the 2 main factors, lagged endogenous together with other lags), a gasoline demand per automobile model (with the 2 main factors, stock of vehicles, and gasoline per previous lagged stock of vehicles), a disaggregate gasoline demand model (with the 2 main factors, other transportation prices, vehicle price, the previous lags of the 2 main factors and endogenous lag), and other models that consist of mixes of those (Dahl & Sterner, 1991). The simple static models that the authors call the intermediate run have an average price elasticity of -0.53. The price elasticities in the short run ranged between -0.08 and -0.41, and those in the long run ranged from -0.23 to -1.05 (Dahl & Sterner, 1991).

A similar but more recent study by Ajanovic, Dahl, and Schipper surveys several types of models in log-log form starting from the “simple static model”, the “distributed lag model” (with the 2 main factors and their previous lags), the “lagged endogenous model”, an “autoregressive model” (without other factors but gasoline consumption), a "vector autoregressive model" (with the previous lags of the 2 main factors and gasoline consumption), a "leading indicator model" (with the previous lags of the 2 main factors), "stock models", and the "characteristics model" (Ajanovic, Dahl & Schipper, 2012, p. 3-4). One of the models that is added from the previous literature is an error correction model with the 2 main factors and their previous lags. The research examines several studies, some of them dated back to the 1970s while some date to the 1990s and 2000s from several countries. The short-run price elasticity most often lies between -0.20 and -0.30 while the long-run elasticity most often lies between -0.60 and -0.85. Price elasticity based on the study with data after 2000 is lower. The researchers explain that increases in wealth and fuel efficiency in vehicles can cause lower shares of fuel expenditures from consumers' pockets. Moreover, they survey new vehicles purchased and miles traveled as endogenous factors for transportation modeling; however, the data deficiency limit the transportation estimation to only more developed nations (Ajanovic et al., 2012). Lin and Zeng also confirm this fact based on their study of gasoline demand in China in 2013. Because there are no official miles-traveled data in China, they estimate the data. With "the poor data quality" and "low" "R-square", they accept that the model cannot fully explain via miles traveled (Lin & Zeng, 2013, p. 196). The paper also recommends not to overlook prices of other fuel types as substitutions, if applicable in some places (Ajanovic et al., 2012). Additionally, "international and domestic air travel", "domestic international waterborne freight", and "rail freight" can be vital today, especially in large countries (Ajanovic et al., 2012, p. 12).

A meta-analysis is also done by Brons, Nikamp, Pels, and Rietveld from 43 studies in several locations. The equation system of price elasticity of gasoline demand and other variables is estimated. They find that the mean short-run and long-run elasticities are -0.34 and -0.84 respectively (Brons, Nijkamp, Pels & Rietveld, 2008).

2.3.2.2 Static Models

Hughes, Knittel, and Sperling conduct a study of short-run price elasticity for gasoline in the U.S. with several types of models from 1975 to 1980 and from 2001 to 2006 to find structural changes between the 2 decades. In their static model, linear, log-linear, and double log functional forms are used with per capita gasoline demand as a dependence variable (Hughes, Knittel & Sperling, 2008). Utilizing ordinary least squares (OLS), Hughes, Knittel, and Sperling's the recent period models produce the elasticity ranging from -0.041 to -0.043 while earlier models provide the elasticity from -0.31 to -0.34. With t-tests and F-tests, they conclude that the beginning 21st century models are statistically different from the 1970s models (Hughes et al., 2008).

Based on a study by Dahl, elasticities are estimated from static models in different countries. The main variables determining gasoline demand are the price of gasoline and income or economic activity. Other variables such as vehicle stock, population density, etc. with non-lags sometimes are added (Dahl, 2012). The study examines already-available studies from "more than 70 countries" in order to compare the evidence between "low-price" nations (the nations were likely to subsidize gasoline prices) and "high-price" nations, and also examines "the energy ladder hypothesis" (i.e., when people become wealthier, they will move towards more efficient fuels) (Dahl, 2012, p. 3). In the countries of her survey including Thailand, the price elasticities for gasoline and diesel are -0.11 to -0.33 and -0.13 to 0.38 respectively. Based on the survey work using 2006 data and her adjustments for fuel policies, her findings indicate that the countries with low gasoline and diesel prices are likely to have a lower price elasticity than the nations with high gasoline and diesel prices, and the poorer nations have a lower price elasticity than the wealthier nations for gasoline. Income elasticities for gasoline range between 0.66 and 1.26, and income elasticity for diesel is 1.34. In this study, Dahl adjusts the elasticities for some countries that have policies promoting fuel switching, especially in European countries and Brazil. However, the adjustment for substitution is not done for Thailand although gasohol blended with ethanol was available during the time of the study. For Thailand, the study indicates price elasticities of -0.16 for gasoline and -0.23 for diesel and income elasticities of 0.91 for gasoline and 1.33 for diesel based on the 2006 data (Dahl, 2012).

Lin and Zeng propose static models in their study for China. The study uses annual data for 30 provinces in the country between 1997 and 2008. Since price and consumption are simultaneously influenced by supply and demand, the endogeneity of the 2 variables should not be ignored. Instruments for the price are thus introduced in the model. The authors mention the prices of refined products, crude prices, and production disruptions employed by some researchers. For this study, Lin and Zeng employ local diesel price and crude price as instruments. They find that both instrumental variables work well when they are separate. The price elasticities are -0.43 for crude price instrument and -0.23 for diesel price instrument (Lin & Zeng, 2013).

Static models sometimes includes variables of price and income interaction. From the same study in 2013, Lin and Zeng add lnP*lnY in one of their equations to examine "the responsiveness of consumers to price changes" when "income changes" (Lin & Zeng, 2013, p. 192-193). It is found that the price elasticity stands at -0.31 to -0.50, and the coefficient of the interaction term accounts for 0.38 to 0.52 (Lin & Zeng, 2013).

Macroeconomic variables can be added to the static models. The same study written by Lin and Zeng proposes unemployment rate and real interest rate in the models. Unemployment rate significantly determines gasoline demand, but real gasoline price becomes an insignificant factor when the model adds both variables. Gasoline price again does not statistically influence gasoline demand when the model has only the unemployment rate variable. However, the model with real interest rate presents significant correlations for real gasoline price, real income, and real interest rate with price elasticity of -0.20. The researchers thus do not recommend the macroeconomic model with unemployment rate due to the small variation of the data (Lin & Zeng, 2013).

2.3.2.3 Dynamic Models

Lin and Zeng utilize annual data from 1997 to 2008 for their partial adjustment models in which demand in the previous period is incorporated in the model. They interpret the coefficient of gasoline price as the short-run elasticity and the coefficient of price over 1 minus the coefficient of gasoline demand in the previous period as the long-run elasticity. Both elasticities are not statistically significant. They explain that the result indicates that the lag term diminishes the influences of the main factors at the present time. Thus, the partial adjustment model is not preferred (Lin & Zeng, 2013).

The cointegration technique has been used frequently and it provides short and long-term elasticities. Bentzen studies gasoline demand in Denmark by using the cointegration technique with annual data from 1948 to 1991. His final model consists of gasoline consumption as an endogenous variable and time trend, real gasoline price, and per capital vehicle stock as exogenous variables (Bentzen, 1994). “Dickey-Fuller tests for stationarity" (Bentzen, 1994, p. 140) are done, and a “cointegration test for stationary residuals” (Bentzen, 1994, p. 141) of the model is performed and found to be cointegrated. The coefficient of gasoline price is -0.41. For the short term, the error correction model (ECM) estimates price elasticity of -0.32. He argues that raising gasoline tax alone increases tax revenues but does not help much to mitigate carbon emissions because of the price inelasticity (Bentzen, 1994).

Alves and Bueno also employ cointegration regressions and ECM to estimate the elasticity for Brazil. The 2 main factors between 1974 and 1999 are used, and yearly alcohol price as a substitute between 1984 and 1999 is introduced in the model (Alves & Bueno, 2003). They find that the variables are cointegrated, so their long-run elasticities from the estimation do not have a spurious regression problem. Coefficients of GDP, gasoline price, and alcohol price are 0.12, -0.46 and 0.48, respectively. The cross price inelasticity is explained by the high investment of engine adaptation. An ECM with first difference provides short-term GDP, gasoline price, and alcohol price elasticities of 0.12, -0.09 and 0.23 respectively; however, the last 2 elasticities are insignificant at 10% level (Alves & Bueno, 2003). Owing to the low substitutability, the authors recommend replacing gasoline with “a new fuel substitution” rather than relying only on alcohol (Alves & Bueno, 2003, p. 191).

Akinboade, Ziramba, and Kumo do a similar research for South Africa. Instead of the Engle and Granger technique done by the previous literature, an unrestricted error correction model (UECM) is utilized (Akinboade, Ziramba & Kumo, 2008). Yearly data between 1978 and 2005 are used in a log-log form. Besides, the 2 main variables, the authors mention “the price of a substitute fuel and vehicle” stock, but they are not included owing to no data availability (Akinboade et al., 2008, p. 3224). Based on their bounds tests, they conclude that a long-run relationship between gasoline demand and the other factors exist. They find that in the long run this method leads to the price elasticity of -0.47 (Akinboade et al., 2008). The inelasticity of demand implies that the “public transportation system” of the nation is “unreliable and inefficient” and a “reliance on private cars”. (Akinboade et al., 2008, p. 3228)

The cointegration technique is also done for petroleum demand in Indonesia by Saad. Similar to the previous study, he utilizes an UECM. Saad uses a log-log form with the data between 1970 and 2005. For the total products consumption model, long-run elasticities range from -0.15 to -0.16. The ECM term provides 50%-52% annual adjustment to equilibrium. For the gasoline share model, long-run elasticities account for -0.016 (Saad, 2009). The study expects to see growth in income which will lead to an increase in fuel consumption; as a result, he suggests the government “promote energy efficiency and conservation” (Saad, 2009, p. 4395).

Iwayemi, Adenikinju and Babatunde estimate elasticities of refined products in Nigeria during 1977-2006 by using yearly data. With the log-log form, they estimate demand for total petroleum products and each product (Iwayemi, Adenikinju & Babatunde, 2010). They use "the augmented Dickey-Fuller (ADF) and Phillips-Perron tests" in the study to test if the "variables are integrated" (Iwayemi et al., 2010, p. 75). They apply a "multivariate maximum likelihood approach" (Iwayemi et al., 2010, p. 75) and find the evidence of "a long-run relationship" (Iwayemi et al., 2010, p. 78). The elasticity of total demand is -0.106 while the elasticity of gasoline is -0.055. When gasoline price in the previous period increases by 1%, demand reduces by 0.249%; however, income does not show a significant effect on gasoline demand in the country. The disequilibrium term represents a response of 10.6% of disequilibrium in the previous period. They finally conclude that although an increase in fuel tax does not substantially decrease fuel consumption, low price elasticity of fuel demand can generate fiscal revenue for other purposes (Iwayemi et al., 2010).

Leesombatpiboon and Joutz examine oil consumption in 7 economic sectors in Thailand. The data employed in this study are annual 1981 2007. The determinants of oil consumption consist of one lag of oil consumption, real price of each petroleum products, the price of electricity as a proxy of the substitute, real GDP, real capital stock, and labor employment, and the lags of those variables (Leesombatpiboon & Joutz, 2010). The dynamic panel analyses show that price elasticity of the whole economy ranges from -0.26 to -0.40 for the short run and from -0.76 to -1.70 for the long run (Leesombatpiboon & Joutz, 2010). Based on "the ADL equilibrium correction framework" which examines each sector separately (Leesombatpiboon & Joutz, 2010, p. 15), price elasticity of transportation sector in the long run is -0.17 which is lower than other sectors while price elasticity of transportation sector in the short run is -0.16. Specifically, for the transportation sector, the authors discuss that although NGV and biofuels played some role recently, constraints in technology lead to price inelasticity (Leesombatpiboon & Joutz, 2010). The authors suggest that with price inelasticity in the transportation sector, the government should "raise oil taxes to generate revenue" which should be used for improving vehicle "efficiency" and increasing "awareness of energy conservation" (Leesombatpiboon & Joutz, 2010, p. 25). Similar to the transportation sector, they recommend using tax revenues to promote energy conservation in the manufacturing sector and the residential and commercial sector, but they suggest that considerably increasing the prices in the residential and commercial sector should be very careful because it can lead to undesirable impacts (Leesombatpiboon & Joutz, 2010).

2.3.2.4 Asymmetric Models

Gately and Dargay conduct an oil demand analysis questioning whether the demand effect of the rising price is the same effect of the falling price. Unlike the studies mentioned in section 2.3.2.1- section 2.3.2.3 that assume perfect reversibility, they believe the effect of the price increase and decrease might asymmetrically reverse.

In 1993, Gately studied crude consumption in the U.S. and Japan questioning why the consumption declines triggered by the price rises of the 1970's is not perfectly moved backward by the price drops of the next decade's (Gately, 1993). Using the data from the 1940s to the 1980s, he points out the fact that, normally, "energy efficiency improvements are irreversible" (Gately, 1993, p. 296) when they are installed or when new equipment is bought. He divides the price into new peaks (Pmax), price reduction (Pcut), and price recovery (Prec). Instead of using petroleum product prices, crude oil price is used as the price due to data availability from 1949 to 1990 (Gately, 1993). For the U.S., the impact of price rises of the 1970's is 7 times higher than the effect of price reductions of the next decade's for transportation oil and about 3 times higher for its non-transportation oil, whereas the evidence from Japan is not clear (Gately, 1993). Consequently, assuming "perfectly price reversibility" like the traditional models probably "overestimates the effect of the price declines" and underestimates the effects of other factors (Gately, 1993, p. 318).

A similar study done by Gately was conducted earlier in 1992 to explore the asymmetric effect of gasoline demand in the U.S. with the data between 1960 and 1990. Again prices are divided into 3 categories, Pmax, Pcut, and Prec. He this time examines 3 endogenous variables which were "vehicle miles per driver" from 1966 to 1989 (Gately, 1992, p. 185), "miles per gallon" from 1966 to 1989 (Gately, 1992, p. 190), and "gasoline demand per driver" from 1960 to 1990 (Gately, 1992, p. 195). For the log-log gasoline consumption model, the goodness of fit statistics does not clearly support 3 types of imperfectly price reversible models, but the asymmetric models have much higher Chow forecast test probabilities than the perfectly reversible models (Gately, 1992).

Dargay and Gately explore the asymmetric effects of demand for transportation fuels in 11 OECD countries during 1961-1990 by using "price decomposition techniques" (Dargay & Gately, 1997, p. 71). Plotting the data for the U.S. and Canada clearly shows the irreversibility. The Wald test of the restriction of the same adjustment of price and income and the reversibility confirms their expectations of the different adjustment and imperfectly price reversibility. The econometric result shows that people respond to new high prices strongly compared with general price movements (Dargay & Gately, 1997). Based on their imperfectly reversible model, short-run elasticities of Pmax, Prec, and Pcut are -0.18, -0.04, and -0.04, respectively, while long-run elasticities of those variables are -0.60, -0.13, and -0.13, respectively. They point out that the average elasticities estimated by ordinary models are likely to be too low during high oil price periods and too high during low oil price periods. (Dargay & Gately, 1997).

A more recent study conducted by Gately and Huntington attempts to explore the asymmetric effects of increasing and decreasing price and income on energy and crude consumption. The paper investigates 96 countries including Thailand between 1971 and 1997 on a per capita basis. The countries are categorized into OECD, oil exporters, income growers (Thailand was in this category), and other countries. The 2 endogenous variables are energy consumption and oil consumption. Again product prices for oil demand models are preferred, but data unavailability, especially in non-OECD countries, leads the authors to use crude price instead. The models incorporate imperfect price and income reversibility (Gately & Huntington, 2002). Panel data analyses for different categories of the nations mentioned above provide some evidence supporting imperfect reversibility. For oil demand models in OECD countries, perfect income reversibility cannot be rejected statistically, but perfect price reversibility can. The oil demand estimation for total non-OECD countries presents both imperfect price and income reversibility, yet the authors note that each of the non-OECD countries are very different. For non-OECD petroleum rich countries, oil price does not significantly influence oil demand, but there is evidence supporting imperfect reversibility for income. For non-OECD emerging countries, there were asymmetric responses for both price and income, with elasticities of -0.12 and 0.95, respectively. For other non-OECD countries, there are imperfect reversibility for both factors, especially when the income declines (Gately & Huntington, 2002).

A summary of the literature for the empirical study of gasoline demand can be found in Appendix B.

Chapter 3

METHODOLOGY

This study explains gasoline demand in Thailand during normal circumstances and oil crises and examines saving measures to provide more options for gasoline consumers to cut their demand while maintaining mobility. Combining quantitative and qualitative analyses, the methodology used in this paper is divided into 3 parts: oil crises and oil saving policies, an empirical study of gasoline demand in Thailand, and oil saving policies for Thailand.

3.1 Oil Crises and Oil Saving Policies

To begin this part, the paper examines the 4 emergency response policies and utilizes the E4 perspectives of energy, economy, equity, and environment to analyze each of the policies. Then, the study focuses on the saving policies from different experiences during a crisis and normal circumstances. Several kinds of saving policies are discussed. The E4 perspectives, the human ecosystem model, and the energy contingency plan are combined and used to analyze the benefits and shortcomings of each saving policies. In this part, the analysis is based on oil importing countries in general and offers lessons learned for Thailand.

3.1.1 Design of the Study

3.1.1.1 Crises and General Emergency Response Plans

This part starts with major oil crises that occurred in the past and provides some sense of the uniqueness of each crisis. Then, it examines the 4 emergency response options including production surges, oil stock drawdowns, fuel switching, and demand restraint. Although the study focuses on dealing with a crisis, and a short-term solution seems likely to be the answer, the paper recommends that policymakers take a longer-term solution into consideration by utilizing the E4 perspectives of energy, economy, equity, and environment for an analysis of each emergency response measure.

3.1.1.2 Saving Measures

This section focuses on various saving measures found in the literature reviewed. Saving measures developed during or after different crises in the U.S., Canada, the U.K., IEA member countries etc. and guidelines from several researchers are discussed. Consumer behavior and attitudes during a crisis and normal circumstances are also discussed. The analysis in this part utilizes a combination of the 3 concepts of E4 perspectives for sustainable development purposes, the application of the human ecosystem model for understanding energy consumption and conservation behavior in transportation, and the energy contingency plan for crisis management purposes. Then, the analysis generates a package of the energy contingency plan from lessons learned for oil-importing nations. The paper discusses strong points, challenges and side effects of each saving policy and other related issues. The saving policies consist of pricing measures (PM), public transit enhancement (PT), carpooling (CP), telecommuting (TC), compressed workweeks (CW), rationing (RT), driving restrictions (DR), non-motorized modes of transportation (NM), and eco-driving (ED). Policy in general (GP) and public information (PI) are also examined because they were found to be important for enhancing the effectiveness of the 9 saving measures.

3.1.2 Sample Selection

Although this study focuses on Thailand, this part examines experiences from other countries for lessons that can be applied to Thailand and other oil-importing nations. Ideally, this part would contain many research articles studying saving measures during a recent crisis in oil-importing developing countries as this would simply and directly apply to the purpose of this study. However, due to the infrequency of oil crises and the relatively short period of shortages (Schueftan, 1983; IEA, 2005b), the data are limited. Limiting the sample to only oil-importing developing countries is also not possible because the information regarding the measures in response to a crisis in such countries is very limited. Each developing country and oil-importing country is unique, but learning from developed countries can offer useful resources for Thailand without repeating the mistakes made by other countries, regardless of whether they are developing or developed countries. Information-rich cases from other countries are thus purposefully selected into the sample. Also included in this study are articles that study conservation during normal circumstances and policies for long-term sustainability. This inclusion helps inform a crisis response plan that incorporates the essence of long-term goals and energy saving behaviors. Unlike quantitative analysis, probabilistic sampling is unnecessary for qualitative research, as the generalization in a statistical sense is not the goal for the research (Merriam, 2009, p. 77). As a result, non-probability sampling based on availability is used in this section. Although non-probability sampling cannot generalize the results, this method can still provide ideas, identify potential challenges, and deliver forewarnings, etc. for policymakers.

3.1.3 Data Collection

The research articles collected are from several fields of study and publicly known journals. The studies from IEA and proceeding papers of related conferences are also included. Direct observation is not used here because the current study is being conducted during a period of low gasoline prices. The study focuses on the evidence found in different places and during events which can provide various dimensions and thoughts for policy planning. Policies implemented by the U.S., Canada, the U.K. and other countries, advice from researchers, evidence from surveys after oil crises, and other important data such as attitudes and behavior toward different oil conservation policies from articles published in standard journals are the sources of this part. Recent articles are preferred, but some articles conducted during the 1970s-1980s are reviewed because some interesting saving policies have not been recently used and some articles provide other interesting information. The list of the reviewed articles is presented in section 4.1.2 at the beginning of each measure. As mentioned in section 3.1.2, several experiences and guidelines come from developed countries because of availability. Although some experiences from developing countries are reviewed, each developing nation is unique. This part of the study aims to provide analyses and identify challenges that policymakers in oil-importing nations might encounter. These can provide useful lessons for Thailand.

The information from this part of the study is later used as the resource for the third part of the study.

3.1.4 Data Analysis

The analysis of this part employs the E4 perspectives (energy, economy, equity, and environment) to briefly analyze production surges, oil stock drawdowns, fuel switching, and demand restraint policies from oil importing nations' perspectives. More attention is paid to the analysis of different saving measures. E4 perspectives for the purpose of sustainability, the human ecosystem model for the purpose of understanding energy consumption and conservation behavior, and the energy contingency plan for the purpose of making emergency plans are incorporated and used to analyze each saving policy based on the information gained from the data collection mentioned in section 3.1.3. More details about E4 perspectives, the human ecosystem model, and the energy contingency plan are discussed in section 2.2 of Chapter 2. This analysis based on the 3 frameworks helps remind policymakers to consider related dimensions and interactions among several factors and helps prevent and mitigate negative side effects of each saving measure.

The incorporation of the 3 frameworks is presented in Table 3.1. A good oil saving policy for coping with a crisis should have a plan to make sure that the implementation process goes well from the beginning to the end. Several energy contingency plans in the U.S. in the past lacked complete performance measures, and their effectiveness was low (Davis, 1983). Criteria for the 8 performance measures have been set up and are used to evaluate each of the implementation strategies since the 1980s in the U.S., but equity and funding resources are often missing (Davis, 1983). Incomplete plans created problems as several measures, such as enhancing public transit and carpooling, often require money. With the long-term goal of sustainability, E4 perspectives are incorporated in the saving policies to ensure that the short-term solution does not deteriorate the long-term sustainable goal. “Equity” is often “overlooked” but is very important, especially in the “free market environment” (Davis, 1983, p. 91) and is thus included in the energy contingency plan. Energy and economic dimensions are already involved with several parts of the plan such as oil demand restraint potential, maintaining mobility and minimizing economic losses, but Davis’ contingency plan does not address the environmental dimension. The analysis in this study includes the environmental dimension, especially in the area of impact assessment. Policymakers with an energy background generally set up a plan aiming to reduce energy consumption as oil supply is disrupted, but they often forget the importance of maintaining mobility and not interrupting peoples’ livelihood. The human ecosystem model employed by Guerin et al. to explain energy consumption and conservation in the household is now used to explain energy conservation in transportation. The policy interventions should understand the interactions among 4 components elaborated in Chapter 2 as a person cannot be completely isolated from the environments (Guerin et al., 2000). Implementing policies without concern for the cold winter when people do not want to walk outside or wait for the bus for a long time, the people whose occupations require them to travel at night, or the cultural norm that discourages sharing rides with strangers for instance, will receive low public acceptability and result in low effectiveness.

Table 3.1 Incorporation of E4 Perspectives,

Human Ecosystem Model, and Energy Contingency Plan

Energy Contingency Plan	E4 Perspectives	Human Ecosystem Model
Pre-implementation activities	Energy, Economy, Equity, Environment	Human organism, Social environment, Natural environment, Designed environment
Contribution to maintaining mobility		
Public acceptability/ information component plan updates		
Demand restraint potential and implementation time		
Funding sources		
Equity considerations		
Monitoring, triggering mechanism, institutional/ legal barriers		
Potential effectiveness/ impact assessments		

Source: Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

In sum, the energy contingency plan incorporating E4 perspectives and the human ecosystem model is used to analyze each oil saving measure in this part of the study.

3.1.5 Validity and Reliability

In this part, the study utilizes lessons learned from different places and times to confirm and crosscheck the experiences in response to several types of oil crises. This ensures internal validity and reliability. Although the various experiences might not translate into a simple policy package for Thailand, the results from this part provide generalized information which can be applied and should be taken into consideration for Thailand and others.

3.1.6 Contributions

First, the paper uses E4 perspectives to analyze the 4 emergency response policies and the 9 saving measures together with the 2 supporting measures, so policymakers can make the urgent solutions more sustainable. Second, the study uses the energy contingency plan (Davis, 1983) combined with E4 perspectives and the human ecosystem model in this analysis to establish and maintain sustainable goals and to enhance the effectiveness of the saving policies through a greater understanding of the interactions between travelers and other environments. Lastly, the results presented in section 4.1 of Chapter 4 are not only the main lessons derived from the third part of this study, but they are also useful resources for oil-importing nations in general.

3.2 Empirical Study of Gasoline Demand in Thailand

Based on the previous econometric literature in Chapter 2, the dependent variables are gasoline demand, gasoline demand per capita, gasoline demand per driver, gasoline combined with diesel demand, oil demand, VMT per capita, VMT per driver, and differences in those variables. The main independent variables are the price of fuel and per capita income or per capita GDP. Other independent variables include real interest rate, unemployment rate, interaction between price and income, time trend, month dummies, a shortage dummy, per capita vehicle stock, number of drivers, the first difference, the lag of the two main independent variables, and the lag of gasoline consumption. The log-log functional form is the most often used, and this study follows the same functional form.

3.2.1 Related Variables

The **dependent variable** in this study is **per capita gasoline consumption (GASQPC)** because the study pays attention to gasoline demand, and VMT or VKT data are unavailable. Using per capita data eliminates the effect of population growth. The consumption per capita rather than per driver is used in the models because the purposes of some trips are originated by passengers' needs, for example, sending children to school, driving family members to a health care provider, and so on. Because there are several grades of gasoline used in Thailand and differences in the ethanol level blended in gasoline produces different heating values, consumption in this study is adjusted by heating values. Exploring gasoline demand by areas (rural and urban) and by incomes (rich and poor) can also prove insightful. However, gasoline consumption data and several other factors in Thailand are not encompassed by those cohorts. Due to the data unavailability, the study instead collects data by regions: **Southern region (SR), Northern region (NR), Central region (CR), Northeastern region (NE), Bangkok (BK)**. Although Bangkok (BK) is geographically located in the Central region, it is different from other provinces in the region because of its urban setting, transit infrastructure, and so on; therefore, the study looks at Bangkok separately. The study also explores **Thailand (TH)** as a whole country. The unit of gasoline consumption is **liters per day per person**.

Independent variables examined in this study consist of 16 factors and 1 instrumental variable (IV). Table 3.2 presents the importance and the expected correlation of each independent variable with the dependent variable.

Table 3.2 Independent Variables and Hypothesis

Independent Variables	Expected Sign	Hypothesis and Explanation
Real gasoline price (GASP)	Baht/liter (-)	With several gasoline grades, the price is weighted by the consumption of the different grades and adjusted by the consumer price index (CPI) of each region. The price elasticity is expected to be negative and inelastic, but the effect of the price during the increasing period (GASPREC) may be different from the effect of the price during the declining period (GASPCUT).
Real Brent crude price (OILP)	Baht/liter (-)	Brent crude oil price is used as an instrumental variable (IV) for GASP. Brent price is potentially correlated with domestic gasoline price but not correlated with the error term. The price is adjusted by Baht/Dollar and the CPI of each region. OILPCUT and OILPREC are also IVs for GASPCUT and GASPREC.
Gross domestic product (chain volume measures with 2002 as	Baht per person (+)	Economic growth is expected to have a positive correlation with GASQPC. Yearly GDP data by region are available, but quarterly data are unavailable. The quadratic match sum method in EViews is used to transform annual GDP to quarterly

Independent Variables	Expected Sign	Hypothesis and Explanation
reference year) (GDP)		data. Population data by region on a yearly basis are available, and the quarterly data are transformed by the quadratic match average method in EViews.
Real diesel price (DIESELP)	Baht/liter (+)	Diesel can be used as a substitute for gasoline. Thus, a positive correlation is expected. At some points, there is more than one grade of diesel. The price, as a result, is weighted by the consumption of different grades of diesel and then adjusted by CPI of each region. DIESELP is also used as an instrumental variable when DIESELP as a substitute fuel is dropped from the models.
Real liquefied petroleum gas price (LPGP)	Baht/liter (+)	LPG can be a substitute for gasoline. Thus, a positive correlation is expected. The price is adjusted by CPI of each region.
Real natural gas price (NATGASP)	Baht/ Kilogram (+)	NGV can be a substitute for gasoline. Thus, a positive correlation is expected. The price is adjusted by CPI of each region.
CPI of public transportation service (TRANSITP)	(+) 2011 as the base year	TRANSITP represents the public transportation fares of each region. Public transportation is a substitute travel mode for the private automobile, so its fares tend to have a positive correlation with gasoline consumption.
Public transportation ridership (TRANSITQ)	Average riders per day (-)	Public transportation is an alternative travel mode for the private automobile. Gasoline consumption tends to increase as the ridership decreases. Only Bangkok provides TRANSITQ yearly data which include bus ridership of the Bangkok Mass Transit Authority

Independent Variables	Expected Sign	Hypothesis and Explanation
		(BMTA) and metro rail ridership of the Bangkok Mass Transit System Public Company Limited (BTS) and the Metropolitan Rapid Transit (MRT). TRANSITQ data do not include travel by taxi, jitney, motorcycle taxi, and so on.
Vehicles or vehicle stock per person (VEHQPC)	Vehicles per person (+)	Vehicle stock should have a positive correlation with GASQPC. The argument that fuel-efficient vehicles and other technologies might create challenges to this thesis is taken into account by using time trends to capture technological influence. More discussion is provided in TREND variable. Both sedans and motorcycles play an important role in Thailand's transportation, but their fuel consumption and VKTs are different. This study transforms the number of motorcycles to sedans by dividing the factor of 2.22 and 7.81 for Bangkok and the factor of 2.22 and 2.76 for the other regions. The fuel consumption rate of sedans is 2.22 times as higher than that of motorcycles (Satiannam, Kedsadayurat, Aransane, and Srisaad, 2013), and the VKT of sedans is 7.81 and 2.76 times as high as that of motorcycles in Bangkok and the other regions, respectively (Limanond, Pongthanaisawan, Watthanaklang, and Sangphong, 2009). Only annual data are available.
New vehicles per person (NEWVEHQPC)	Vehicles per person (+)	Like VEHQPC, NEWVEHQPC can be an option to explore the relationship between vehicle stock and gasoline consumption. The advantage of

Independent Variables	Expected Sign	Hypothesis and Explanation
		NEWVEHQPC is the availability of both annual and quarterly data. However, VEHQPC is preferred in yearly models because VEHQPC covers all registered automobiles and subtracts the vehicles with canceled registrations. Although NEWVEHQPC is not presumably as accurate as VEHQPC, quarterly NEWVEHQPC is used due to its availability.
CPI of vehicle purchase (VEHP)	(-) 2011 as the base year	VEHP is used as a proxy of the cost to own automobiles. The higher cost of owning a vehicle is likely to discourage driving and reduce gasoline consumption. Because VEHP, VEHQPC, and NEWVEHQPC are directly or indirectly related to vehicle stock, only one of these variables is selected in a model at a time. VEHQPC is the first option to choose for a yearly model as it includes old and new vehicles. NEWVEHQPC is the first option for a quarterly model as VEHQPC is not available. VEHP is the last option if the other 2 variables do not fit the model. The reason for this is that vehicle stock should directly correlate with fuel consumption while the cost of having vehicles indirectly determines fuel consumption, and VEHP cannot identify vehicles by fuels.
Proportion of GDP from the non-agricultural	Percentage (+/-)	Economic activities at the sector level might play an essential role in gasoline consumption. Being more industrialized is expected to increase gasoline consumption. In contrast, it is possible that economic

Independent Variables	Expected Sign	Hypothesis and Explanation
sector over total GDP (AGGDP%)		development might lead to more efficient use of energy due to better urban planning and land use, better transit infrastructure, and so on. The proportion of non-agricultural GDP (industrial and service sector) to total GDP is a proxy of the level of industrialization.
Unemployment rate (UNEMP%)	Percentage (-)	The unemployment rate is another macroeconomic factor which might influence gasoline consumption, especially through commuting to work. A higher unemployment rate is likely to reduce driving.
Seasonal dummy (QUARTER1 QUARTER2 QUARTER3)	Dummy set (Quarter 3 was expected to be -)	Seasonality can influence gasoline consumption via driving behavior, economic activity, and cultural and special events. In places where tourism plays a significant role, gasoline consumption might be influenced by high/low season of travel. In some areas, the extreme weather might stimulate a desire for convenience. For Thailand, March to mid-May is considered summer time. Mid-May to October is the rainy season while November to February is winter time. However, the weather in the Southern region differs from other regions. Quarter 3 is expected to have a negative effect because of the rainy season and fewer special events to stimulate travel.
An oil shock that existed during a particular time (OILSHOCK)	Dummy (-)	An oil crisis refers to a dramatically rising oil price arising from excess demand. The condition can come from supply disruptions or high demand expansion during which physical shortages might not occur. This

Independent Variables	Expected Sign	Hypothesis and Explanation
		study refers to the shocks from the Oxford Institute for Energy Studies' oil price shocks (Economou, 2016). During a crisis, gasoline consumption is likely to be lower because of altruistic behavior and difficulties of purchasing fuels.
Time trend variable (TREND)	Time trend (+/-)	Adding a time trend variable is an easy way to capture trends which generally exist in economic variables (Wooldridge, 2009). Moreover, TREND can also represent other factors such as technological development, infrastructure development, telecommunication, etc. which have not been identified by the variables stated above. Economic development is likely to increase gasoline consumption; however, more fuel-efficient vehicles, electric vehicles, extended transit networks, ability to telecommute, etc. might decrease gasoline consumption.
Huge flooding in Bangkok in 2011 (FLOOD)	Dummy (-)	Massive flooding during the fourth quarter of 2011 affected several parts of Bangkok; moreover, those whose property was not harmed were afraid of possible flooding and kept their cars in higher places such as higher levels of garage buildings, bridges, expressways, and so on. Other floods and the 2011 floods in other areas are excluded because they did not generate as extensive and concentrated an effect on driving as the flooding in 2011 in Bangkok.

3.2.2 Model Specification

The dependent variable in the model of this study is GASQPC or per capita gasoline consumption. Based on the literature reviewed in Chapter 2, dynamic models by cointegration technique, static models, and asymmetric models are employed. The cointegration technique is useful as it can highlight short-term and long-term relationships. This section begins with dynamic models by cointegration technique, followed by static and asymmetric models.

3.2.2.1 Dynamic Models by Cointegration Technique

Cointegrating regressions and error correction models (ECM) are often used as mentioned in the literature reviewed. The time series economic data used in this study are likely to have a unit root; consequently, the regression result becomes invalid (Stock and Watson, 2011). However, if the dependent variable and independent variables are both non-stationary but are cointegrated, the spurious regression problem is resolved, and the regression result represents an equilibrium relationship. In contrast, if the dependent variable and independent variables are both non-stationary and they are not cointegrated, the regression result becomes spurious and invalid. In other words, the regression result misleadingly suggests a high correlation even though there is no real correlation (Stock & Watson, 2011).

Conducting a cointegration technique begins with checking the order of integration of the variables or testing for stationarity. After that, the relationship between the independent and the dependent variables is examined by the cointegrating regression which represents the long-run relationship if cointegration is present (Equation 1).

Thirdly, the residuals from the cointegrating regression are tested for stationarity by using an Augmented Dickey-Fuller (ADF) Fisher Test. This Engle-Granger test for cointegration has critical values which differ from the usual critical Dickey-Fuller values (Stock & Watson, 2011). If the test finds that cointegration is present, the fourth step examines an ECM which provides the short-term relationship and speed of adjustment to an equilibrium (Equation 2). If the dependent and independent variables of Equation 1 are cointegrated, the equilibrium error is stationary, and the coefficient of ECM term (u_{t-1}) should be negative as equilibrium is restored.

A cointegration technique is used with the panel yearly data which have 5 regional cross sections (Southern region, Northern region, Central region, Northeastern region, and Bangkok) and either 13 time periods (2003-2015) or 15 time periods (2001-2015) depending on the independent variables contained in a model. To be clearer, some independent variables such as LPGP and NATGASP are just used as substitutes for gasoline since 2003, and UNEMP% data are available since 2001 even though several independent variables can be traced back to the 1990s. More detail about the data sources and periods of each variable can be found in section 3.3.2. The models are cross-section fixed effect but not period fixed effect. The period fixed effect is not conducted because the models already contain TREND and OILSHOCK; moreover, to forecast gasoline consumption in the future, one needs to assume the fixed effect of the future period.

The natural logarithm is taken to the dependent variable (GASQPC), price variables (GASP, DIESELP, LPGP, NATGASP, TRANSITP, and VEHP), and GDP. Additionally, VEHQPC, NEWVEHQPC or VEHP is used in a model. In other words, VEHQPC in equation 1 and 2 could be switched to NEWVEHQPC, VEHP, or its lag. Quarterly data are analyzed by the cointegration technique if the panel annual data are found to be cointegrated.

Equation 1 Cointegrating regression for 5 regions in Thailand with annual data where i = 5 regions, and t = 13 or 15 periods

$$
\begin{aligned}
LN(GASQPC_{it}) \\
&= \beta_0 + \beta_1\, LN(GASP_{it}) + \beta_2\, LN(GDP_{it}) + \beta_3\, LN(DIESELP_{it}) \\
&+ \beta_4\, LN(LPGP_{it}) + \beta_5\, LN(NATGASP_{it}) + \beta_6\, LN(TRANSITP_{it}) \\
&+ \beta_7\, (VEHQPC_{it}) + \beta_8\, (AGGDP\%_{it}) + \beta_9\, (UNEMP\%_{it}) \\
&+ \beta_{10}\, OILSHOCK_{it} + \beta_{11} TREND_{it} + u_{it}
\end{aligned}
$$

Equation 2 Error correction model for 5 regions in Thailand with annual data where i = 5 regions, and t = 13 or 15 periods

$$
\begin{aligned}
d(LN(GASQPC_{it})) \\
&= \beta_0 + \beta_1\, d(LN(GASP_{it})) + \beta_2\, d(LN(GDP_{it})) + \beta_3 d\, (LN(DIESELP_{it})) \\
&+ \beta_4\, d(LN(LPGP_{it})) + \beta_5\, d(LN(NATGASP_{it})) \\
&+ \beta_6\, d(LN(TRANSITP_{it})) + \beta_7\, (d(VEHQPC_{it})) + \beta_8 (d(AGGDP\%_{it})) \\
&+ \beta_9\, (d(UNEMP\%_{it})) + \beta_{10}\, OILSHOCK_{it} + \beta_{11} TREND_{it} + \gamma u_{it-1} \\
&+ v_{it-1}
\end{aligned}
$$

3.2.2.2 Static Models

Static models here consist of simple static models and two-stage least squares (and instrumental variables). Regressions based on the 2 types are conducted on yearly and quarterly data. Again the natural logarithm is taken to the dependent variable (GASQPC), the price variables (GASP, DIESELP, LPGP, NATGASP, TRANSITP, and VEHP), and GDP. VEHQPC, NEWVEHQPC or VEHP is used in a yearly model while NEWVEHQPC or VEHP is used in a quarterly model because quarterly VEHQPC is not available. Panel analyses of annual and quarterly data are performed, as shown in equation 3.1 and 3.2, and the time series analyses are done if the panel analyses do not adequately explain the correlation.

Equation 3.1 Panel analysis with the simple static model for 5 regions in Thailand with annual data where i = 5 regions, and t = 13 or 15 periods

$$
\begin{aligned}
LN(GASQPC_{it}) \\
&= \beta_0 + \beta_1\, LN(GASP_{it}) + \beta_2\, LN(GDP_{it}) + \beta_3\, LN(DIESELP_{it}) \\
&+ \beta_4\, LN(LPGP_{it}) + \beta_5\, LN(NATGASP_{it}) + \beta_6\, LN(TRANSITP_{it}) \\
&+ \beta_7\, (VEHQPC_{it}) + \beta_8\, (AGGDP\%_{it}) + \beta_9\, (UNEMP\%_{it}) \\
&+ \beta_{10}\, OILSHOCK_{it} + \beta_{11} TREND_{it} + u_{it}
\end{aligned}
$$

Equation 3.2 Panel analysis with the simple static model for 5 regions in Thailand with quarterly data where i = 5 regions, and t = 52 or 60 periods

$$
\begin{aligned}
LN(GASQPC_{it}) &\\
&= \beta_0 + \beta_1 LN(GASP_{it}) + \beta_2 LN(GDP_{it}) + \beta_3 LN(DIESELP_{it}) \\
&+ \beta_4 LN(LPGP_{it}) + \beta_5 LN(NATGASP_{it}) + \beta_6 LN(TRANSITP_{it}) \\
&+ \beta_7 (NEWVEHQPC_{it}) + \beta_8 (AGGDP\%_{it}) + \beta_9 (UNEMP\%_{it}) \\
&+ \beta_{10} OILSHOCK_{it} + \beta_{11} TREND_{it} + \beta_{12} QUARTER1_{it} \\
&+ \beta_{13} QUARTER2_{it} + \beta_{14} QUARTER3_{it} + u_{it}
\end{aligned}
$$

The panel analyses have 5 regional cross sections and 13 or 15 year periods as did equations 1 and 2 of the cointegration technique. The models are done with both fixed effect and non-fixed effect. The non-fixed effect models assume that the relationships between each independent and the dependent variable of the 5 regions are the same. In contrast, cross-section fixed effect questions whether the relationships among the 5 regions are different. The differences among the regions are tested by the redundant fixed effect test which is in EViews. Again, the period fixed effect is not conducted.

Economic time series data are usually non-stationary. An OLS estimation of their regressions can be spurious, which is the phenomenon of finding a relationship between those unrelated non-stationary variables because of the existence of trends and unit roots. The regression results are invalid. Thus, the study tests for non-stationarity. If there is evidence of a unit root, the first difference of equations 3.1 and 3.2 is employed. Then the study needs to ensure that the first difference of those variables became stationary. The

Phillips-Perron Fisher unit root test in EViews is utilized to check a unit root of each variable, and the null hypothesis is the existence of a unit root. If the level of each variable is found to have a unit root, but its first difference is found to be stationary, taking the first difference for equations 3.1 and 3.2 (except for the dummy variables) becomes the solution for the spurious problem.

Equation 4.1 First difference of panel analysis with the simple static model for 5 regions in Thailand with annual data where i = 5 regions, and t = 12 or 14 periods

$$\begin{aligned} d(LN(GASQPC_{it})) &= \beta_0 + \beta_1\, d(LN(GASP_{it})) + \beta_2\, d(LN(GDP_{it})) + \beta_3 d\, (LN(DIESELP_{it})) \\ &+ \beta_4\, d(LN(LPGP_{it})) + \beta_5\, d(LN(NATGASP_{it})) \\ &+ \beta_6\, d(LN(TRANSITP_{it})) + \beta_7\, (d(VEHQPC_{it})) + \beta_8 (d(AGGDP\%_{it})) \\ &+ \beta_9\, (d(UNEMP\%_{it})) + \beta_{10}\, OILSHOCK_{it} + u_{it} \end{aligned}$$

Equation 4.2 First difference of panel analysis with the simple static model for 5 regions in Thailand with quarterly data where i = 5 regions, and t = 51 or 59 periods

$$\begin{aligned} d(LN(GASQPC_{it})) &= \beta_0 + \beta_1\, d(LN(GASP_{it})) + \beta_2\, d(LN(GDP_{it})) + \beta_3\, d(LN(DIESELP_{it})) \\ &+ \beta_4\, d(LN(LPGP_{it})) + \beta_5\, d(LN(NATGASP_{it})) \\ &+ \beta_6\, d(LN(TRANSITP_{it})) + \beta_7\, d(NEWVEHQPC_{it}) \\ &+ \beta_8\, d(AGGDP\%_{it}) + \beta_9\, d(UNEMP\%_{it}) + \beta_{10}\, OILSHOCK_{it} \\ &+ \beta_{11} QUARTER1_{it} + \beta_{12} QUARTER2_{it} + \beta_{13} QUARTER3_{it} + u_{it} \end{aligned}$$

In equations 4.1 and 4.2 with the first difference, the original intercepts that appeared in equations 3.1 and 3.2 do not now appear because they are time-invariant and cancel out during the differencing. The intercepts of equations 4.1 and 4.2 now represent TREND. Cross-section fixed effect and non-fixed effect are still performed after taking the first difference.

The study questions whether each region is unique and whether the correlation between each independent and the dependent variable differ among the regions, not just in the constants of the cross-section fixed effects. As a result, the regional dummy variables are added for each independent variable. The modified equations 4.1 and 4.2 replace d(LN(GASP)) with d(LN(GASP))*DSR + d(LN(GASP))*DNR + d(LN(GASP))*DCR + d(LN(GASP))*DNE + d(LN(GASP))*DBK, replace d(LN(GDP)) with d(LN(GDP))*DSR + d(LN(GDP))*DNR + d(LN(GDP))*DCR + d(LN(GDP))*DNE + d(LN(GDP))*DBK, and so on. This technique is applied for all independent variables except for the seasonal dummy. Another modification is to replace the regional dummy for only one independent variable at a time.

Another type of static model conducted in the study is two-stage least squares (TSLS) and an instrumental variable model. Endogeneity might exist in the consumption function as gasoline price might be jointly determined with gasoline consumption. The endogeneity can cause omitted variables and errors in variables problems, so OLS does not provide consistent parameter estimates (Wooldridge, 2009). Two-stage least squares and the instrumental variable technique can be used to cope with endogeneity if the instrumental variable has a high correlation with gasoline price but no correlation with the unobserved shocks to gasoline demand. Brent crude oil price (OILP) in Thai Baht and adjusted by regional CPI is used as an instrumental variable because OILP is exogenous and highly correlated with GASP as indicated in Table 3.3. DIESELP is another candidate and tested in this study; however, DIESELP in several models is used as a price of substitute goods influencing GASQPC.

Table 3.3 Correlation between GASP and OILP by Regions and Data Types

Correlation	d(log(GASP)) and d(log(OILP))					
	TH	SR	NR	CR	NE	BK
Quarterly data	0.8638	0.8675	0.8631	0.8646	0.8629	0.8616
Yearly data	0.8538	0.8600	0.8483	0.8602	0.8581	0.8487

However, Thailand is a small country having relatively small oil consumption and imports compared with world oil consumption. Unlike China, the U.S. and other primary oil consumers, Thailand's oil consumption does not significantly influence the world oil market and production. In other words, GASP should be exogenous. Thus, the study should not produce the endogeneity problem. However, two-stage least squares and OILP and DIESELP as instrumental variables are conducted to confirm that there is no endogeneity problem and that the simple static model is valid.

The first stage begins with regressing d(LN(GASP)) on d(LN(OILP)) and the other independent variables, which are exogenous. Equations 5.1 and 5.2 represent the second stage which regresses d(LN(GASQPC)) on other independent variables and the forecasted d(LN(GASP)) gained from the first stage. EViews makes the process easier by allowing the choice of the TSLS method and plugging in d(LN(OILP)) as the instrumental variable. The Hausman Test for Endogeneity with the null hypothesis of no endogeneity in EViews is performed to test whether TSLS is needed,

Equation 5.1 First difference of panel analysis with TSLS static model for 5 regions in Thailand with annual data where i = 5 regions, and t = 12 or 14 periods

$$
\begin{aligned}
d(LN(GASQPC_{it}))
&= \beta_0 + \beta_1\, d(LN(\widehat{GASP}_{it})) + \beta_2\, d(LN(GDP_{it}) + \beta_3 d\, (LN(DIESELP_{it})) \\
&+ \beta_4\, d(LN(LPGP_{it})) + \beta_5\, d(LN(NATGASP_{it})) \\
&+ \beta_6\, d(LN(TRANSITP_{it})) + \beta_7\, (d(VEHQPC_{it})) + \beta_8 (d(AGGDP\%_{it})) \\
&+ \beta_9\, (d(UNEMP\%_{it})) + \beta_{10}\, OILSHOCK_{it} + u_{it}
\end{aligned}
$$

Equation 5.2 First difference of panel analysis with TSLS static model for 5 regions in Thailand with quarterly data where i = 5 regions, and t = 51 or 59 periods

$$
\begin{aligned}
d(LN(GASQPC_{it}))
&= \beta_0 + \beta_1\, d(LN(\widehat{GASP}_{it})) + \beta_2\, d(LN(GDP_{it})) \\
&+ \beta_3\, d(LN(DIESELP_{it})) + \beta_4\, d(LN(LPGP_{it})) + \beta_5\, d(LN(NATGASP_{it})) \\
&+ \beta_6\, d(LN(TRANSITP_{it})) + \beta_7\, d(NEWVEHQPC_{it}) \\
&+ \beta_8\, d(AGGDP\%_{it}) + \beta_9\, d(UNEMP\%_{it}) + \beta_{10}\, OILSHOCK_{it} \\
&+ \beta_{11} QUARTER1_{it} + \beta_{12} QUARTER2_{it} + \beta_{13} QUARTER3_{it} + u_{it}
\end{aligned}
$$

A time series analysis is done as an alternative method. When the panel analysis does not work well, the time series analysis (with separated regions) becomes the primary method. The Phillips-Perron Fisher unit root test in EViews is employed to investigate a unit root of each variable by region separately. The first difference is used in this study as the data are likely to have a unit root.

For the time series analysis, yearly simple static models and quarterly simple static models are the same as equations 4.1 and 4.2, respectively, but $i = 1$ or each region because each region is analyzed separately. Bangkok, which is different from the others and has more data available, examines public transportation ridership (TRANSITQ) additionally for the yearly model and examines flooding in Bangkok in the last quarter of 2011 (FLOOD) for the quarterly model. For TRANSITQ, the model replaces TRANSITQ with TRANSITP because they are highly correlated. TRANSITQ of Bangkok is available only in yearly data, not quarterly data while the huge flood in 2011 impacted driving in Bangkok for about a quarter, not a whole year. The additional yearly Bangkok model and the additional quarterly Bangkok model are presented in equations 4.3 and 4.4.

Equation 4.3 Time series analysis with the simple static model for Bangkok with annual data

$$d(LN(GASQPC_t))$$
$$= \beta_0 + \beta_1\, d(LN(GASP_t)) + \beta_2\, d(LN(GDP_t)) + \beta_3 d\,(LN(DIESELP_t))$$
$$+ \beta_4\, d(LN(LPGP_t)) + \beta_5\, d(LN(NATGASP_t)) + \beta_6\,(d(TRANSITQ_t))$$
$$+ \beta_7\,(d(VEHQPC_t)) + \beta_8(d(AGGDP\%_t)) + \beta_9\,(d(UNEMP\%_t))$$
$$+ \beta_{10}\, OILSHOCK_t + u_t$$

Equation 4.4 Time series analysis with the simple static model for Bangkok with quarterly data

$$d(LN(GASQPC_t))$$
$$= \beta_0 + \beta_1\, d(LN(GASP_t)) + \beta_2\, d(LN(GDP_t)) + \beta_3\, d(LN(DIESELP_t))$$
$$+ \beta_4\, d(LN(LPGP_t)) + \beta_5\, d(LN(NATGASP_t)) + \beta_6\, d(LN(TRANSITP_t))$$
$$+ \beta_7\, d(NEWVEHQPC_t) + \beta_8\, d(AGGDP\%_t) + \beta_9\, d(UNEMP\%_t)$$
$$+ \beta_{10}\, OILSHOCK_t + \beta_{11} QUARTER1_t + \beta_{12} QUARTER2_t$$
$$+ \beta_{13} QUARTER3_t + \beta_{14} FLOOD_t + u_t$$

Time series yearly TSLS static models and time series quarterly TSLS static models of each region are the same as equations 5.1 and 5.2, respectively, but i = 1 or each region because each region is analyzed separately. Again for Bangkok, additional models which include TRANSITQ in the yearly model and include FLOOD in the quarterly model are presented in equations 5.3 and 5.4, respectively. Like the panel analysis, d(LN(OILP)) is the instrumental variable. The Hausman Test for Endogeneity with the null hypothesis of no endogeneity in EViews is performed as well.

Equation 5.3 Time series analysis with TSLS static model for Bangkok with annual data

$$d(LN(GASQPC_t)) = \beta_0 + \beta_1 \, d(LN(\widehat{GASP}_t)) + \beta_2 \, d(LN(GDP_t)) + \beta_3 d\,(LN(DIESELP_t)) + \beta_4 \, d(LN(LPGP_t)) + \beta_5 \, d(LN(NATGASP_t)) + \beta_6 \, (d(TRANSITQ_t)) + \beta_7 \, (d(VEHQPC_t)) + \beta_8 (d(AGGDP\%_t)) + \beta_9 \, (d(UNEMP\%_t)) + \beta_{10} \, OILSHOCK_t + u_t$$

Equation 5.4 Time series analysis with TSLS static model for Bangkok

with quarterly data

$$d(LN(GASQPC_t)) = \beta_0 + \beta_1 \, d(LN(\widehat{GASP}_t)) + \beta_2 \, d(LN(GDP_t)) + \beta_3 \, d(LN(DIESELP_t)) + \beta_4 \, d(LN(LPGP_t)) + \beta_5 \, d(LN(NATGASP_t)) + \beta_6 \, d(LN(TRANSITP_t)) + \beta_7 \, d(NEWVEHQPC_t) + \beta_8 \, d(AGGDP\%_t) + \beta_9 \, d(UNEMP\%_t) + \beta_{10} \, OILSHOCK_t + \beta_{11} QUARTER1_t + \beta_{12} QUARTER2_t + \beta_{13} QUARTER3_t + \beta_{14} FLOOD_t + u_t$$

3.2.2.3 Asymmetric Models

It is likely that after a crisis, people might buy more fuel-efficient vehicles. Also, after switching to NGV, LPG, or electricity, consumers might not move back to gasoline even though gasoline could still fuel their vehicles. This is because the prices of substitute fuels are competitive with gasoline. Gately and Huntington examine the asymmetric effect by decomposing the crude oil price to Pmax, Prec, and Pcut (Gately & Huntington, 2002) as mentioned in Chapter 2. In this study, the asymmetric models examine the different effects of increasing gasoline price (GASPREC) and decreasing gasoline price (GASPCUT) by OLS. Then the Wald test that the null hypothesis of the coefficient of GASPCUT is equal to the coefficient of GASPREC is conducted. Unlike the previous studies, Pmax is not included in this study because OILSHOCK is present in the models; moreover, the weighted price of gasoline (from different grades) is used instead of crude oil price. With the first difference, d(LN(GASPCUT)) and d(LN(GASPREC)) are the negative growth of gasoline price and the positive growth of gasoline price, respectively.

Equation 6.1 Panel and time series analyses with the asymmetric model for 5 regions in Thailand and each region with annual data

where i = 5 regions for panel analysis and i = 1 for 1 region, and t = 12 or 14 periods

$$
\begin{aligned}
d(LN(GASQPC_{it})) &= \beta_0 + \beta_1\, d\big(LN(GASPCUT_{it})\big) + \beta_2\, d(LN(GASPREC_{it})) \\
&+ \beta_3\, d(LN(GDP_{it})) + \beta_4 d\, (LN(DIESELP_{it})) + \beta_5\, d(LN(LPGP_{it})) \\
&+ \beta_6\, d(LN(NATGASP_{it})) + \beta_7\, d(LN(TRANSITP_{it})) \\
&+ \beta_8\, (d(VEHQPC_{it})) + \beta_9 (d(AGGDP\%_{it})) + \beta_{10}\, (d(UNEMP\%_{it})) \\
&+ \beta_{11}\, OILSHOCK_{it} + u_{it}
\end{aligned}
$$

Equation 6.2 Panel and time series analyses with the asymmetric model for 5 regions in Thailand and each region with quarterly data

where i = 5 regions for panel analysis and i = 1 for 1 region, and t = 51 or 59 periods

$$d(LN(GASQPC_{it}))$$
$$= \beta_0 + \beta_1\, d(LN(GASPCUT_{it})) + \beta_2\, d\big(LN(GASPREC_{it})\big)$$
$$+ \beta_3\, d(LN(GDP_{it})) + \beta_4\, d(LN(DIESELP_{it})) + \beta_5\, d(LN(LPGP_{it}))$$
$$+ \beta_6\, d(LN(NATGASP_{it})) + \beta_7\, d(LN(TRANSITP_{it}))$$
$$+ \beta_8\, d(NEWVEHQPC_{it}) + \beta_9\, d(AGGDP\%_{it}) + \beta_{10}\, d(UNEMP\%_{it})$$
$$+ \beta_{11}\, OILSHOCK_{it} + \beta_{12} QUARTER1_{it} + \beta_{13} QUARTER2_{it}$$
$$+ \beta_{14} QUARTER3_{it} + u_{it}$$

Equation 6.3 Time series analysis with the asymmetric model for Bangkok with annual data

$$d(LN(GASQPC_t))$$
$$= \beta_0 + \beta_1\, d\big(LN(GASPCUT_t)\big) + \beta_2\, d\big(LN(GASPREC_t)\big)$$
$$+ \beta_3\, d(LN(GDP_t) + \beta_4 d\ (LN(DIESELP_t)) + \beta_5\, d(LN(LPGP_t))$$
$$+ \beta_6\, d(LN(NATGASP_t)) + \beta_7\, (d(TRANSITQ_t)) + \beta_8\, (d(VEHQPC_t))$$
$$+ \beta_9 (d(AGGDP\%_t)) + \beta_{10}\, (d(UNEMP\%_t)) + \beta_{11}\, OILSHOCK_t + u_t$$

Equation 6.4 Time series analysis with the asymmetric model for Bangkok with quarterly data

$$d(LN(GASQPC_t)) = \beta_0 + \beta_1\, d\big(LN(GASPCUT_t)\big) + \beta_2\, d\big(LN(GASPREC_t)\big) + \beta_3\, d(LN(GDP_t)) + \beta_4\, d(LN(DIESELP_t)) + \beta_5\, d(LN(LPGP_t)) + \beta_6\, d(LN(NATGASP_t)) + \beta_7\, d(LN(TRANSITP_t)) + \beta_8\, d(NEWVEHQPC_t) + \beta_9\, d(AGGDP\%_t) + \beta_{10}\, d(UNEMP\%_t) + \beta_{11}\, OILSHOCK_t + \beta_{12} QUARTER1_t + \beta_{13} QUARTER2_t + \beta_{14} QUARTER3_t + \beta_{15} FLOOD_t + u_t$$

3.2.3 Data and Sources

The study uses the 3 types of models (static and instrumental variable models, the cointegration technique, and the asymmetric model) to examine gasoline consumption in Thailand. However, there are several sub-models within those 3 models. The first dimension of the models is the different econometric techniques: static, dynamic and asymmetric models as explained above. The second dimension is the different data frequency: quarterly data and annual data. The third dimension is the different regions (Southern region, Northern region, Central region, Northeastern region, and Bangkok). Because of limited regional data, only main independent variables and shorter periods are conducted.

Some factors can be traced back to 1993 or earlier. However, the study does not use data before 1991 because gasoline price was regulated until mid-1991. The study examines the national level and the regional levels. Although the regional levels have limited data, the study can differentiate specific characteristics across the regions, and this might provide a better view for policymakers to design more appropriate measures for each region to some degree. Details of years and sources of each variable are presented in Table 3.4.

Table 3.4 Data and Sources for Empirical Study of Gasoline Demand in Thailand

Data	Detail	Period	Sources
Gasoline consumption by region (Million liters per day)	Gasoline sales which include petroleum gasoline and gasohol sales. Gasohol is adjusted by British Thermal Unit (BTU)	1993-2015 (Annual and quarterly data adjusted from monthly data)	Energy Policy and Planning Office (1993-1999) Department of Energy Business (2000-2015)
Gasoline price (Baht per liter)	Retail gasoline price weighted by the consumption of each gasoline grade	1993-2015 (Annual and quarterly data adjusted from monthly data)	Bank of Thailand (1993-2002) Energy Policy and Planning Office (2003-2015)
Consumer price index by region	General CPI with the 2011 reference year	1993-2015 (Annual and quarterly data)	Bureau of Trade and Economic Indices, Ministry of Commerce

Data	Detail	Period	Sources
Crude oil price (USD per barrel)	Brent price#	1993-2015 (Annual and quarterly data)	U.S. Energy Information Administration
Exchange rate (Baht per USD)	Thai Baht per U.S. dollar	1993-2015 (Annual and quarterly data)	Bank of Thailand
Diesel consumption by region (Millions of liters per day)	Diesel sales which include petroleum diesel and biodiesel sales.	1993-2015 (Annual and quarterly data adjusted from monthly data)	Energy Policy and Planning Office (1993-1999) Department of Energy Business (2000-2015)
Diesel price (Baht per liter)	Retail diesel price weighted by the consumption of each diesel grade	1993-2015 (Annual and quarterly data adjusted from monthly data)	Bank of Thailand (1993-2002) Energy Policy and Planning Office (2003-2015)
GDP by region (Million Baht)	Chain volume measure Gross Regional Product (GRP) with the 2002 reference year (Thailand starts publishing the chain volume series in May 2015)	1995-2015 (Annual data)	Office of the National Economic and Social Development Board (NESDB)
GDP by region (Million Baht)	Chain volume measure Gross Regional Product (GRP) with the 2002	1995-2015 (Quarterly data)	Frequency conversion by EViews (Quadratic Match Sum method)

Data	Detail	Period	Sources
	reference year (Thailand started publishing the chain volume series in May 2015)		
CPI of public transportation	Price index of public transportation fares with the 2011 reference year	1993-2015 (Annual and quarterly data)	Bureau of Trade and Economic Indices, Ministry of Commerce
BMTA bus ridership	Bangkok Mass Transit Authority (BMTA) bus ridership in Bangkok	1993-2015 (Annual data)	Bangkok Mass Transit Authority
BTS train ridership	Bangkok Mass Transit System Public Company Limited (BTS) metro rail ridership in Bangkok	1999-2015 (Annual data)	Bangkok Mass Transit System Public Company Limited
MRT train ridership	Metropolitan Rapid Transit (MRT) rail ridership in Bangkok	2005-2015 (Annual data)	Metropolitan Rapid Transit
CPI of vehicle purchase	Price index of vehicle purchase with the 2011 reference year	1993-2015 (Annual and quarterly data)	Bureau of Trade and Economic Indices, Ministry of Commerce
The number of vehicles by region (Vehicles)	The number of sedans and motorcycles that are registered with Department of Land Transportation	1998-2015 (Annual data)	Department of Land Transportation

Data	Detail	Period	Sources
The number of new vehicles (Vehicles)	The number of new sedans and motorcycles that are registered with Department of Land Transportation	1999-2015 (Annual and quarterly data)	Department of Land Transportation
Non-agriculture GDP by region (Million Baht)	Chain volume measure non-agriculture GRP with the 2002 reference year	1995-2015 (Annual data)	Office of the National Economic and Social Development Board (NESDB)
Non-agriculture GDP by region (Million Baht)	Chain volume measure non-agriculture GRP with the 2002 reference year	1995-2015 (Quarterly data)	Frequency conversion by EViews (Quadratic Match Sum method)
Unemployment rate by region (Percentage)	People aged over 15 years old who do not work but are searching for jobs or do not search for jobs but are ready to work	2001-2015 (Annual and quarterly data)	Bank of Thailand#
Population by region (Persons)	The population of each region	1995-2015 (Annually)	Office of the National Economic and Social Development Board (NESDB)
Population by region (Persons)	The population of each region	1995-2015 (Quarterly)	Frequency conversion by EViews (Quadratic Match Average method)

3.2.4 Contributions

The study looks the most updated gasoline demand for Thailand at the regional level with the combination of the static, dynamic, and asymmetric models. Economic structure and industrialization effect as independent variables are examined. Moreover, Thailand's GDP data in chain value series which were just launched in May 2015, replacing the conventional GDP, are utilized in the study. Consequently, the analysis contributes new findings based on the model's dimensions, new GDP data, economic structure and industrialization effects, and regional dimensions.

3.3 Oil Saving Policies for Thailand

The first part of this study (Oil Crises and Oil Saving Policies) provides information about emergency response plans and oil saving measures in general, not specifically for Thailand. The second part of the study (Empirical Study of Gasoline Demand in Thailand) provides facts and figures of how gasoline price and other important parameters impact gasoline consumption in Thailand. Moreover, this part offers a clearer picture of the demand pattern specifically for Thailand. Based on the literature reviewed in Chapter 2, it can be hypothesized that gasoline consumption is not highly sensitive to gasoline price and income with a slow adjustment to a new equilibrium. Thus, the government will likely need to act before people will respond to a crisis and ease the situation. The third part of the study (Oil Saving Policies for Thailand) combines the evidence found in the first and the second parts. Furthermore, the third part of the study utilizes additional qualitative and quantitative evidence unique to the context of Thailand in order to reveal information specific to Thailand that the quantitative method in the second part of the study alone does not capture, for example, complaints about sidewalks, satisfaction with transit services, responses from citizens if prohibited measures are implemented, and so on. Figure 3.1 presents the methodology used in the 3 parts of the study and shows how each of them is related.

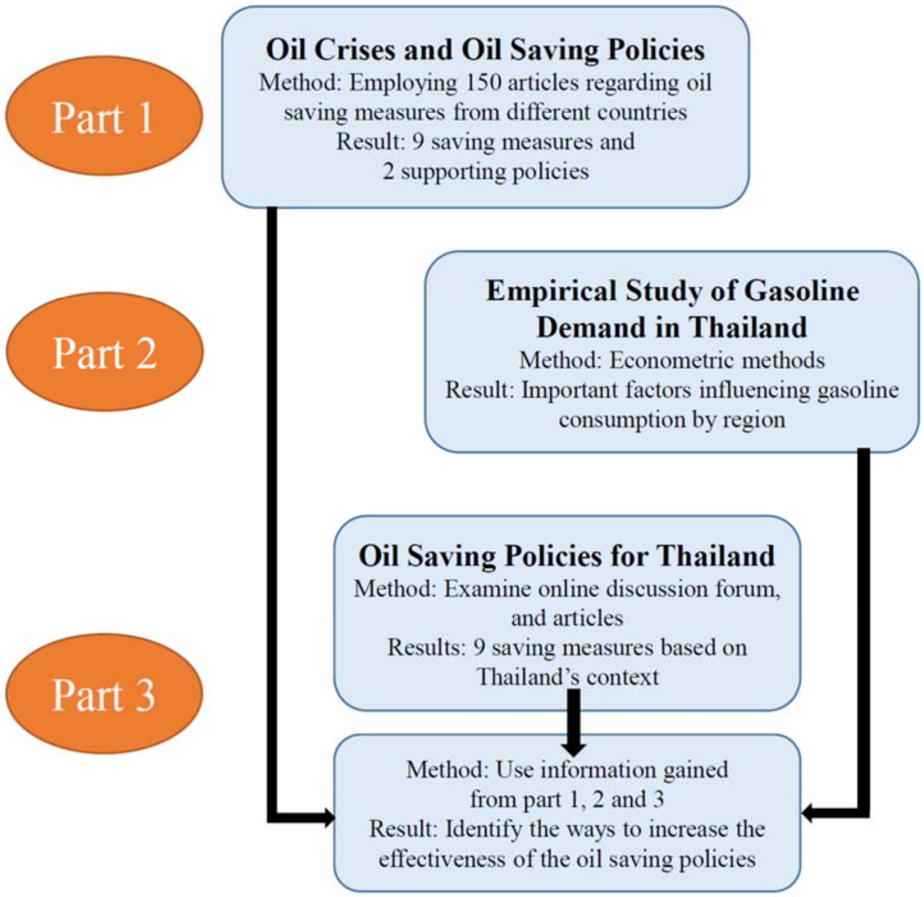

Figure 3.1 Methodology of the Study

3.3.1 Design of the Study

The primary purpose of the third part of the study is to identify appropriate oil saving measures for Thailand and to increase their effectiveness. The study combines the information found in the first and the second parts, and additional information such as facts and figures about Thailand from an online discussion forum and articles.

Although interviews and surveys are useful, they are not employed in this study because of resource constraints. A good survey requires time, a budget and teamwork to collect information from different groups of people in different regions, as well as special requirements, and so on. A survey can be conducted well if done by a proper organization instead of an individual researcher who has a limited budget and time. Moreover, to increase accuracy, the information involving a past crisis requires a fresh memory to respond the survey; however, oil prices during the last few years have not been high. Thus, the expense of a survey might not be worthwhile. Non-response rates and missing data make surveys even more expensive. Related information from government units and articles, and the data from a Thai online discussion forum are thus employed in this part as they can reflect similar data to some degree without the travel, rent space, time consumption, and other pecuniary costs (Cowley & Radford-Davenport, 2011; Ferrante et al., 2016).

Using an asynchronous online discussion forum, researchers can collect information from hard-to-reach populations who are geographically dispersed (Ferrante et al., 2016) or socially isolated (Seale, Charteris-Black, MacFarlane & McPherson, 2010). This source of information can deliver more carefully constructed responses and provide the opportunity to transfer related information and scientific studies (Ferrante et al., 2016; Seale et al., 2010). With the unidentifiable private information of an online forum, higher willingness to reveal information honestly, more participation from shy people (Ferrante et al., 2016; Seale et al., 2010), and greater revelation of intimate or embarrassing information (Seale et al., 2010) are significant advantages over face-to-face conversations. With a variety of matters, an online discussion forum can avoid the expurgation, influence, and information that are perhaps unintentionally filtered by interviewers and questionnaires (Seale et al., 2010). Compared with a focus group, an online discussion forum can avoid bias from a few dominant voices (social dominance issue) and can cope with the busy schedule of each participant, as the asynchronous online forum does not require people to be present at the same time and place (Cowley & Radford-Davenport, 2011). Additionally, an online discussion forum is a valuable source (Carcioppolo, Chudnovskaya, Gonzalez & Stephan, 2016) before engaging in other costly forms of data collection (Seale et al., 2010).

However, some researchers believe that systematic bias can still occur because online forum participants are likely to repeat previously shared information (Hamilton, Schlosser & Chen, 2017), and it is possible that people are unwilling to address minority opinions that are then drowned in the online forum (Nekmat & Gonzenbach, 2013), but at least it is a place that these opinions are expressed more freely (Seale et al., 2010). Another drawback of the forum is that it may result in diluted responsibility (as participants can leave the forum anytime) and low effectiveness in terms of coming to a reasonable conclusion at the end (Lewinski, 2010; McClean, 2011). However, it still shows complexity of views (McClean, 2011), and understanding an issue might not always need agreement or a conclusion (McClean, 2011). Moreover, an online discussion forum is viewed as a community-driven knowledge site or a peer-to-peer support community because it is free, convenient for participants and can maintain confidentiality (Sauls, Whitlock & Leidheiser, 2016) especially for sensitive topics (Seale et al., 2010). Frequently mentioned problems with online discussions are the lack of nonverbal cues, the inability to see body language, the shallowness of information for some online posts, the existence of sampling biases as participants need to use the Internet in general and be logged in to the forum (Ferrante et al., 2016), as well as the inability (for researchers) to ask follow-up questions (Ferrante et al., 2016). However, more people are familiar with communicating electronically. This may reduce the sampling bias (Ferrante et al., 2016), and the use of emojis and video clips can mitigate some of the other limitations.

With the advantages and the minor disadvantages of the data from an online discussion forum stated above, there are more serious disadvantages which this study should not overlook. The credibility of the data from an online discussion forum is questionable (Sauls et al., 2016) and there is no guarantee that what participants claim to experience is real (Seale et al., 2010). Several researchers mention limits on the generalizability of the data from an online discussion forum (Carcioppolo et al., 2016; Hamilton et al., 2017; Kozin et al., 2015) and limits on the demographic context (Seale et al., 2010) because forum participants are anonymous. The study tries to lessen the problems by incorporating related articles and information from government units with the data from the online discussion forums and also incorporating the quantitative evidence from the second part of this study. Because of the generalization limitation and system bias, the study does not pay attention to what percentage or how many people agree with a particular policy, how many people tend to violate the implemented saving measure, and so on. The study aims to examine various reflections among Thai people and the issues which policymakers should prepare for. Studies incorporating details of people in particular communities or having particular socioeconomic characteristics are important but are recommended for future studies

3.3.2 Sample Selection

The information used in this part is from the results of the first and the second part of the study (presented in section 4.1 and 4.2, respectively) and from an online discussion forum and related articles.

The information from the first part of this study is from non-probability sampling as mentioned in section 3.1.2 because the information from oil importing developing nations is limited but purposeful sampling can still reveal some ideas, potential challenges, forewarnings, etc. for policymakers. The study determined that, regardless of geographic location or time frame, people have similar intuitions and respond to a crisis in similar ways. They react similarly to measures such as attempts to reduce the cost of transportation during an emergency, their willingness to cooperate with their governments under some conditions but not under others is similar, etc. Globalization also generalizes people around the world to some degree. Thus, several experiences and guidelines from developed countries are still useful for the third part of the study. However, different countries and different eras generate unique contexts regarding infrastructure, political systems, and so on. Consequently, simply and directly applying those experiences and policies to Thailand's case is not a good choice.

Information about Thailand comes from 2 primary sources. The first source is the information from the second part of this study, based on secondary data from government units between 1993 and 2015 as stated in section 3.2. In addition to the quantitative data and its results, the study tries to obtain information about Thailand via an online discussion forum and articles from government units and researchers. The Pantip forum is selected because it is the biggest Thai community website. Alexa.com ranked the Pantip forum as the most popular Thai community website in 2015, and the site ranked number 5 out of all websites surfed by Thai people. The forum messages are publicly available online for viewing, and registration and password are not required. The participants identify themselves utilizing pseudonyms. The forum was searched for Thai and English keywords for each saving measure. Other qualitative data come from the articles written by government units and researchers found using the Google web search engine. The information from the Pantip forum and the articles found from the Google search are categorized by the 9 saving measures using policy keywords in the Thai and English languages.

3.3.3 Data Collection

The information and results from the study in the first part and the second part are the primary data sources of this part. The information which has not been mentioned in sections 3.1 and 3.2 is the information from the Pantip forum and the articles from the Google search. This information reflects how Thai people think and respond to saving measures and sheds light on what the government should do. The data are expected to show the reasons why people do not want (or want) to ride public transit and do not want (or want) to bike, the reasons why they use less energy intensive modes of transportation, what they expect if the prohibited measures are enforced, how they expect their government to respond to a crisis, and so on. Figure 3.1 presented at the beginning of section 3.3 explains how each part of the study is related and finally how it generates the third part of the study. Table 3.5 presents the data collection of the third part while Tables 3.6 and 3.7 provide more detail on the data from the Pantip forum and the articles from the Google search which are not mentioned in sections 3.1 and 3.2. The data from the Pantip forum were collected between October 2017 and November 2017 while the Google articles are from a search done in November 2017. The related threads on the Pantip forum are from the first 120 threads found, and the related articles are from the first 100 results found and from government documents. After screening, it is found that 171 threads from the forum are related to the measures, and 41 articles from Google search and government documents are related to the measures. Some of the related threads and articles apply to more than 1 policy category. For the online discussion forum, this study does not focus on how many forum messages agree with or concern on particular issues. This study pays more attention to various opinions and issues pointed out by the forum participants. Institutional Review Board approval and informed consent from the forum participants are not required because the forum messages are publicly available online for viewing, and there is no intervention or interaction with the individual forum participants. Moreover, identifiable private information cannot be obtained.

Table 3.5 Data Collection for Thailand's Oil Saving Policies

Data Description	Source of Data
Experiences and guidelines of oil saving policies from other countries	Results of the first part of the study (presented in section 4.1 Oil Crises and Oil Saving Policies)
Important factors such as the price of gasoline, GDP, vehicle stock, public transit fare, seasonality, oil shock, etc. which influence Thailand's gasoline consumption	Results of the second part of the study (presented in section 4.2 Empirical Study of Gasoline Demand in Thailand)
Opinions and facts from Thai people and government units in response to oil saving policies if they are imposed	Pantip online discussion forum and related articles found on Google search

Table 3.6 Data Collection from the Pantip Online Discussion Forum

Policy Category	Keyword	Related Threads	Original Post Date, Last Post Date
PM	High oil prices, Oil prices jump	22	December 12th, 2007 – February 11th, 2017
PT	Metro rail, Public bus	35	January 9th, 2013 – November 18th, 2017
CP	Carpool	23	January 9th, 2013 – May 26th, 2017
TC	Telecommunication	13	May 24th, 2013 – February 3rd, 2017
CW	Compressed workweek	9	October 22nd, 2013 – April 24th, 2017
RT	Rationing	3	July 17th, 2011 –

Policy Category	Keyword	Related Threads	Original Post Date, Last Post Date
			April 2nd, 2013
DR	Driving restriction	17	March 16th, 2013 – November 22nd, 2016
ED	Eco-driving, Speed limit	36	January 11th, 2013 – August 25th, 2017
NM	Biking, Walking to work, Sidewalk	32	June 11th, 2013 – November 15th, 2017

Table 3.7 Data Collection for Articles

Policy Category	Keyword/ Government Document	Author, Year
PM, ED	Study Oil Prices Increase	National Statistical Office, 2007#
PM	Study Oil Prices Increase	Office of Industrial Economics, 2008
PM	Study Oil Prices Increase Subsidy	Tangkitvanich & Kansuntisukmongkol, 2007
PM	Study Oil Prices Increase Subsidy	Koomsup & Sirasoontorn, 2007
PM	Government Document	Energy Policy and Planning Office, 2009
PM	Government Document	Energy Policy and Planning Office, 2008
PM	Government Document	National Energy Policy, 1995

Policy Category	Keyword/ Government Document	Author, Year
PM	Government Document	Energy Policy and Planning Office, 2005
PT	Study Public Transit	Bangkok Department of City Planning, 2012b
PT	Study Public Transit	Kemapetch & Kidbunjong, 2014
PT	Study Public Transit	Kraingoo, 2010
PT	Study Public Transit	Panklang, 2005
PT	Study Public Transit	Kheawsanun, 2004
PT	Study Public Transit	Srisinlapanan, 2006
PT	Study Public Transit	Poorat, 2005
PT	Study Public Transit	Chuanchuen, 1996#
CP	Government Document	National Energy Policy Office, 1999
CP, ED	Research Carpool	Kusombutt, 2013
CP	Research Carpool	Laosirihongthong, Tongsrisoontorn & Silakong, 2000
TC	Government Document	National Statistical Office, 2013
TC	Government Document	National Statistical Office, 2015a
CW	Government Document	Department of Labor Protection and Welfare, 2017
CW	Study Work for 10 Hours	Job DST, 2017
CW	Research Work for 10 Hours	Phoncharern, 2007
CW	Research Work for 10 Hours	Girdsuwan, 1980
RT	Research Oil Rationing	Fuel Allotment Act of 1940 (B.E. 2483), 1940

Policy Category	Keyword/ Government Document	Author, Year
RT, DR	Research Oil Rationing	Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516), 1973
RT, PM	Research Oil Rationing	Wisansuwannakorn, 2006
DR	Study Driving Restriction Odd- Even day	Thailand Daily News, 2016
ED	Study Eco-Driving	Federation of Thai Industries, 2014
ED	Study Eco-Driving	Seniwongs, 2015
ED	Study Eco-Driving	Tongsook, 2011
ED	Study Eco-Driving	Ienergyguru, 2015
NM	Study Biking Walking	Phala & Bejrananda, 2016
NM	Study Biking Walking#	Pulkasiwit & Tason, 2015
NM	Study Biking Walking	Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015
NM	Study Biking Walking	Rachatapiti & Jiamphao, 2015
NM	Research Sidewalk	Kuabpimai, 2013
NM	Research Sidewalk	Chinorak & Dankittikul, 2015
NM	Research Sidewalk	Nirathorn, 2014
NM	Research Sidewalk	Bangkok Department of City Planning, 2012a

3.3.4 Data Analysis

The data from the online forum are categorized into 9 measures along with the policy categories from in the first part of the study. Each policy category has several threads and each comment is manually coded with the help of Microsoft Excel to detect what issues concern Thai people, why they choose or do not choose certain actions or options, who or what they believe is to blame for the crisis conditions, how they think about the government and policies, and so on. The information from government documents and articles and information gained from the second part of the study increase the credibility and the power of generalizations which might be questioned if the data from the online forum were used alone. The study then gains the opinions, facts, criticisms, and suggestions from Thailand people from several sources.

After that, the study compares and combines the information gained from the first part which comes from other countries' experiences and guidelines. The incorporation of E4 perspectives, the human ecosystem model, and the energy contingency plan employed in the first part is applied to identify appropriate policies for Thailand.

3.3.5 Validity and Reliability

The study utilizes lessons learned from different places and times to confirm and crosscheck the experiences in response to a crisis. The data obtained from the Pantip forum are used to apply these lessons to Thailand. The online forum provides several advantages such as including the voices of those who do not generally speak out, opinions of those who live far from urban centers, and avoidance of expurgation, influence, and information that perhaps are unintentionally filtered by interviewers and questionnaires. Credibility and generalization are improved by incorporating articles, government documents, and the quantitative analysis from the second part of this study.

The findings are not limited to petroleum gasoline but can also apply to other types of fuels. Based on the AEDP 2015, Thailand plans to increase the penetration of biofuels in transportation. Although petroleum gasoline remains important, the study can be applied to biofuels as well. Future crises might come from drought, high food prices, land use problems, and so forth, and biofuel saving measures can be implemented for crises from any of these causes. Moreover, the country might transform its sources of fuels from biofuels to electricity generated by 100% renewable energy. In this case, this study can be applied during power supply disruptions such as severe weather, inaccurate weather forecasts, disruptions in storage units, battery disposal problems, high prices of metals and minerals, and so on.

3.3.6 Contributions

Apart from the contributions stated in section 3.1.6 for the first part of the study and section 3.2.3 for the second part of the study, the study offers oil saving policy recommendations for policymakers using E4 perspectives (energy, equity, economy, and environment), the human ecosystem model, and the energy contingency plan. Additionally, policy recommendations are established from the experiences from other nations, the guidelines for emergency response plans, and the quantitative and qualitative information applied to the context of Thailand. The paper provides an information package for Thailand’s policymakers to implement oil saving policies which support the long-term goals of energy, economy, equity, and environment in more efficient ways. Also, the saving measures used during a crisis can be sustained after a crisis once the situation returns to normal or be applied to the longer term as the study reminds policymakers to use a long-term solution to solve a crisis which is viewed as a short-term problem.

Chapter 4

RESULTS OF THE STUDY

4.1 Oil Crises and Oil Saving Policies

4.1.1 Oil Crises and Response Measures

Oil supply disruptions and rising oil prices can negatively impact the economies of oil-importing nations and the livelihoods of their populations. This section aims to briefly review past oil crises and response measures before paying more attention to saving policies in section 4.1.2.

The IEA lists major oil disruptions and the gross peak supply loss since the 1950s (IEA, 2014) as shown in Table 4.1. During the 6 decades from 1956 to 2016, there were 12 major disruptions; on average a significant disruption occurred every 5 years. Although the amount of oil loss is one of the vital causes of the severity of the problem, inventory levels, the duration of the disruption and the available spare production capacity at the time of each crisis were very important as well. Because each oil supply disruption had unique characteristics (IEA, 2014), policymakers must carefully consider each of them individually. Besides specific supply disruptions, strong demand and stagnant supply occurred between January 2003 and June 2008 generating price shocks (Economou, 2016). Moreover, before an actual physical disruption, the oil market already expects and responds to the news.

Table 4.1 Major Oil Disruptions

Date	Supply disruptions	Gross peak supply loss (million barrels per day)
Nov 1956 – Mar 1957	Suez crisis	2.0
Jun 1967 – Aug 1967	Six-day war	2.0
Oct 1973 – Mar 1974	Arab-Israeli war and Arab oil embargo	4.3
Nov 1978 – Apr 1979	Iranian revolution	5.6
Oct 1980 – Jan 1981	Outbreak of Iran-Iraq war	4.1
Aug 1990 – Jan 1991	Iraqi invasion of Kuwait	4.3
Jun 2001 – Jul 2001	Iraqi oil export suspension	2.1
Dec 2002 – Mar 2003	Venezuelan strike	2.6
Mar 2003 – Dec 2003	War in Iraq	2.3
Sep 2005	Hurricanes Katrina/Rita	1.5
Sep 2008	Hurricanes Gustav/Ike	1.3
Feb 2011 – Oct 2011	Libyan civil war	1.5

Source: Adjusted from IEA, 2014

Response measures that both IEA and non-IEA member nations generally plan to use are production surges, stock draws, fuel switching, and saving measures as mentioned in section 2.3.1.1 of Chapter 2.

Aiming for sustainability, both long-run and short-run energy policies should consider E4 perspectives. The measures to respond an oil crisis are analyzed here employing E4 perspectives. The summary of response measures using E4 Perspectives is presented in Table 4.2.

- The Energy Perspective: Production surges and stock draws can increase the oil supply in the market during a crisis, so energy security and accessibility are likely to increase. However, a long-period crisis depletes the domestic reserve quickly, especially in countries with a low reserve and low emergency stocks. Coping with a crisis by utilizing the 2 supply-side measures generates a greater carbon lock-in in a long-term crisis because the nations have to invest in better oil production and exploration technology or invest in larger stockpiling facilities. Saving measures do not increase oil supply but decrease oil demand. Energy security can diminish the limitations on accessibility and mobility. Fuel switching can improve energy security. Unlike the 2 supply-side measures, both fuel switching and saving measures reduce oil dependency.

- The Economy Perspective: Production surges and stock draws increase the supply into the market and mitigate a disruption effect on the economy; however, holding oil stocks raises both the cost of oil itself and the cost of maintaining the oil. These costs ultimately pass to consumers. Saving measures might limit mobility and negatively affect the economy depending on the available travel options and the details of each measure. Fuel switching creates a new fuel economy and maintains mobility.

- The Equity Perspective: The 4 response measures can generate both negative and positive impacts depending on the details of each measure. Although production surges and stock draws allow additional oil into the market, energy poverty might not decrease if the additional supply cannot calm the market down to the point that the poor can afford to purchase fuel. Saving measure seems to be superior to other measures, but without a well-designed measure, the rich still have more ability to circumvent the measure to fit their needs. Fuel switching requires some investment in the new substitutes and installations, but the poor might not be able to invest.

- The Environment Perspective: The 2 supply-side measures continuously generate pollution because they do not reduce consumption and production. Additionally, production surges might lead the government to relax some regulations for a short time such as oil-well safety conditions, which raises the risk of damaging wells and reservoirs. The carbon lock-in of the supply-side measures deteriorates environment in the longer term. Saving measures reduce consumption and reduce emissions at least for a short time. Fuel switching can potentially mitigate environmental impacts depending on the new fuels and how new problems, presented by the use of batteries, mineral exploration, and so on, are managed.

Table 4.2 Summary of Response Measures via E4 Perspectives

Measure	Energy	Economy	Equity	Environment
Production surges	+/-	+	+/-	-
Stock draws	+/-	+/-	+/-	-
Fuel switching	+	+	+/-	+/-
Saving measure	+	+/-	+/-	+

Note: + positive impact, - negative impact

Oil saving policies might not harm the nation as some people think; moreover, they have the potential to bring a country to sustainable development in the long term. However, some negative impacts can occur, and the effectiveness of the policy can be questioned if implemented without a good plan. Section 4.1.2 reviews various oil saving policies from different experiences and offers lessons learned for Thailand and other oil-importing nations.

4.1.2 Oil Saving Policies

This section reviews 150 papers from several countries. After reviewing them, the study categorizes oil saving policies into 9 measures (pricing measures, public transit enhancement, carpooling, telecommuting, compressed workweeks, rationing, driving restrictions, non-motorized modes of transport, and eco-driving) and 2 related policies (public information and a general policy) which should be used to support the 9 saving measures. Please note that the idea and information contained in section 4.1 come from the reviewed articles listed in the tables shown at the beginning sections of the measures. The author categorizes and analyzes the idea and information by employing the energy contingency plan (Davis, 1983) with the incorporation of E4 perspectives (Johansson, 2005) and the human ecosystem model (Guerin et al., 2000) for each saving policy as elaborated in Chapter 3.

4.1.2.1 Pricing Measures

Twenty-eight of the 150 research articles are related to pricing measures. The reviewed articles for pricing measures are presented in Table 4.3.

Table 4.3 Data Collection for Pricing Measures

Authors, Year	Areas, Methodology
Adom, Amakye, Barnor, Quartey & Bekoe, 2016	Ghana, Econometric models
Anderson, 1983	U.S., Experiences

Authors, Year	Areas, Methodology
Bajo-Buenestado, 2016	Spain, Econometric models
Brunso, 1983b	U.S., Comments and experiences
Burke & Nishitateno, 2013	132 countries, Data 1995-2008 and Econometric models
Cheon, Urpelainen & Lackner, 2013	137 countries, Econometric models
Cunado, Jo & Perez de Gracia, 2015	Japan, Korea, India, Indonesia, Structural VAR model
Dahl, 2012	124 countries including Thailand, Literature survey
Dahl & Sterner, 1991	Several Countries, Literature survey
Dartanto, 2013	Indonesia, Computable General Equilibrium (CGE)
Dennis, 2016	Several countries including Thailand, Computable General Equilibrium (CGE)
Dillon, Saphore & Boarnet, 2015	U.S. (CA), Data from NHT Survey and Generalized Structural Equation Modeling (SEM)
Gillingham, 2014	U.S. (CA), Econometric model
Humphrey, 1983a	U.S., Interview from the public and private sector
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Ju, Su, Zhou & Wu, 2017	China, Path analysis
Kaplowitz & McCright, 2015	U.S., Online surveys
Lin & Prince, 2013	U.S., Econometric models
Naranpanawa & Bandara, 2012	Sri Lanka, Computable General Equilibrium (CGE)

Authors, Year	Areas, Methodology
Noland, Polak, Bell & Thorpe, 2003	U.K. (London, South East, and North East), Telephone survey after the crisis ended for 2 months
Rentschler, 2016	Nigeria, Statistical simulation model
Roberts, Vera-Toscano & Phimister, 2015	U.K., Panel data analysis, descriptive analysis, and discrete hazard models
Scott, 2015	29 countries, Uncertainty-augmented model
Shi & Sun, 2017	China, Econometric model
Siddig, Aguiar, Grethe, Minor & Walmsley, 2014	Nigeria, Global applied general equilibrium (AGE) model and MyGTAP model
Soile & Mu, 2015	Nigeria, Benefit Incidence Analysis (BIA) and households data 2009/2010
Solaymani & Kari, 2014	Malaysia, Computable General Equilibrium (CGE) Model
Zhang, Broadstock & Cao, 2014	China, Planned consumption framework

The articles before the late 1980s from developed countries discuss the negative effects and the inefficient allocation of price controls (Brunso, 1983b; Lee, 1983) and encourage the adoption of price allocations or the free market. The articles from the last 3 decades from developed countries talk about increasing costs of travel, but mention the difficulties of implementing such measures during a crisis (IEA, 2005b). In contrast, developing countries attempt to find ways to remove oil subsidies, whereas increasing travel costs is considered undesirable. Unlike the IEA's pricing measures which focus on raising costs of travel for developed countries, this section pays more attention to phasing out oil subsidization. The important issues regarding pricing measures include:

- The price elasticity is very low especially in the short run (Adom et al., 2016, Burke & Nishitateno, 2013, Dahl, 2012, Dahl & Sterner, 1991). Oil-importing countries tend to have higher price elasticity than oil-exporting countries because of high oil taxes and the tendency to buy fuel-efficient cars (Burke & Nishitateno, 2013). When the volatility of fuel price in the past years is elevated, the elasticity tends to be small as people have adjusted their behavior (Lin & Prince, 2013).

- During a period of stable prices, elasticity is less elastic than in a period of rising prices (Gillingham, 2014). In other words, during a crisis, people try to find ways to adjust their behavior by reducing their travel or shifting modes of travel (Noland et al., 2003).

- High oil prices and shortages produce a serious economic disruption (Humphrey, 1983a, p. 61; Zhang et al., 2014), and especially impact "fuel poverty in rural areas" and for vulnerable households (Roberts et al., 2015, p. 222). However, the causes of rising prices might generate impacts on different economies; as a result, policymakers should consider the reasons behind the shocks (Cunado et al., 2015).

- Measures to increase costs of travel become difficult to implement during a crisis (IEA, 2005b; Brunso, 1983b). Even during normal circumstances, increasing oil taxes is frequently questioned and receives strong opposition (Kaplowitz & McCright, 2015) sometimes leading to protests (Noland et al., 2003).

- During normal circumstances, raising oil taxes can gain more support if the tax increases gradually and if the tax to build up revenue is used for all citizens equally (Kaplowitz & McCright, 2015).

- Price controls discourage oil producers from raising their production (Brunso, 1983b) whereas a market approach sends the price signal to consumers to cut their demand significantly (Anderson, 1983). Moreover, price controls make a fuel-efficient transportation policy less effective. Although the government is tempted to reduce the price, the government should not distort price signals (IEA, 2005b).

- Gasoline consumers are more negatively sensitive to gasoline tax changes than pre-tax changes because of the persistence of price increases (Bajo-Buenestado, 2016) and “expected future gasoline prices” (Bajo-Buenestado, 2016, p. 121, Scott, 2015).

- Price elasticity is generally low, but travel for commuting, business, and education purposes are less sensitive than other travel purposes (IEA, 2005b; Dillon et al., 2015). Driving in the U.S. is more negatively responsive to gasoline price (higher negative) when a household has a higher income as the rich possibly have more ability to adapt their travel behavior (Gillingham, 2014). The income elasticity in a country tends to lower as income increases (Dahl, 2012). Living in urban or rural areas can also generate different price elasticities and responses to rising prices (Gillingham, 2014).

- In addition to socioeconomic variation, the variation in sociodemographic characteristics can generate different travel behaviors and differing responses to a change in fuel prices (Dillon et al., 2015). Different types of owners also respond to fuel price adjustments differently. The driving behavior of those using company vehicles is not significantly sensitive to gasoline price rises (Gillingham, 2014).

- Oil subsidies generate several negative impacts. Oil subsidies create environmental destruction, discourage efficient consumption, require high government expenditures (Cheon et al., 2013; Dartanto, 2013; Dennis, 2016; Rentschler, 2016), cause lower budget allocations to “health care, education, infrastructure, and other profitable public investment” (Cheon et al., 2013, p. 383), and generally generate inefficient systems to assist targeted groups of people (Cheon et al., 2013; Dartanto, 2013; Dennis, 2016; Rentschler, 2016). The subsidies worsen income distribution (as the wealthy gain the most significant benefit from gasoline subsidies); distort fuel price signals; increase environmental damage (Dartanto, 2013; Dennis, 2016; Siddig et al., 2014); “generate opportunities for corruption, speculation, and smuggling” (Dartanto, 2013, p. 123); deteriorate long-term economic growth (Shi & Sun, 2017); and discourage research and development (Ju et al., 2017).

- Removing petroleum subsidies can increase energy efficiency in transportation (Adom et al., 2016; Burke & Nishitateno, 2013) and reduce emissions (Burke & Nishitateno, 2013; Solaymani & Kari, 2014). Also, price distortions benefit some parts of the economy (Ju et al., 2017; Shi & Sun, 2017). However, removing fuel subsidies without compensation is likely to receive substantial “objections and political challenges” (Dartanto, 2013, p. 123), and create more “poverty and inequality” (Dartanto, 2013, p. 123), especially for the urban poor (Dartanto, 2013; Naranpanawa & Bandara, 2012; Siddig et al., 2014). Thus, the government needs to gradually phase out oil subsidies and transfer the subsidies from the middle and high-income group to the low-income group (Dartanto, 2013) and other targeted groups (Dennis, 2016; Naranpanawa & Bandara, 2012).

- The income transfer process should prevent corruption (Siddig et al., 2014) and should ensure that the benefits of the redistribution system go to the right groups (Soile & Mu, 2015). The right timing to phase out the fuel subsidies is also vital to prevent widespread protests (Soile & Mu, 2015). Because compensation can mitigate the shock impacts varying among regions, disaggregated social assistance and tailored strategies are found to be more effective (Rentschler, 2016).

- The countries with oil-rich resources and a frail institutional capacity are likely to offer higher oil subsidies; to reduce oil subsidies, the countries have to upgrade their institutional capacity (Cheon et al., 2013).

- An analysis of pricing measures is presented in Table 4.4. Because an increase in oil taxes and an attempt to increase costs of travel aggravate consumer tensions and burdens during a crisis, measures to increase taxes and travel costs are unwise to utilize in developing countries during a crisis. Hence, the pricing measures here are attempts to remove existing subsidies while maintaining the market price system. It seems that the government does nothing, but actually many actions are required to maintain the market price system and reduce negative impacts of a crisis.

Table 4.4 Analysis of Pricing Measures

Energy Contingency Plan	Pricing Measures
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Gradual elimination of fuel subsidies to minimize the negative impacts and possible protests - Collect and update data of vulnerable groups that need quick attention if a crisis occurs - Provide compensation or assistance for appropriate groups - Set up regulations that might prevent the need for future fuel subsidization during a crisis - Transfer oil taxes to infrastructure creation such as public transit, bicycle infrastructure, etc. so that consumers have other less fuel-intensive travel options at an affordable price, which can protect consumers from rising oil prices and oil shortages in the future.
Contribution to maintaining mobility (Use price allocation and provide some assistance for targeted groups with the understanding of HO, NE, SE, DE to better achieve the E4 goals)	- An indirect contribution since the price allocation is more efficient than the subsidy, leads to fuel saving, and leads to higher production - Need to offer less fuel-intensive travel modes along with pricing measures to maintain mobility, especially for vulnerable groups
Public acceptability/ information component and plan updates (Understanding the interactions among HO,	- Generate a fair subsidy-phasing-out system and compensation for vulnerable groups and provide information to increase public acceptance - Update the database and make sure that all the needy receive appropriate supports

Energy Contingency Plan	Pricing Measures
NE, SE, DE can increase public acceptance)	- Increase public awareness regarding the necessity of maintaining the market price and the connection between oil taxes and fair budget allocation to health care, education, less fuel-intensive transportation infrastructure, and other social benefits - Disseminate the information that people can receive other forms of assistance rather than just compensation for particular groups and the information about available travel options and trip reduction measures as pain-relievers; the information and options should be suitable for the audience and time; for example, disseminating information about free shuttles that connect bus stations and mass rapid transit stations during cold winters to increase transit riders' comfort or for those who work at night
Demand restraint potential and implementation time (Efficient resource allocation which can meet the E4 goals if the vulnerable groups are supported appropriately)	- Maintaining the market price at all time makes other saving policies more effective - Have the ability to reduce fuel consumption - Need to increase the price elasticity of demand for more conservation through several less fuel intensive travel options and other saving measures such as working from home, and compressed workweeks - Take time to implement the assistance programs
Funding sources (Economy, equity)	- No requirement because of no subsidy - Need to ensure that oil taxes are efficiently and fairly allocated for other saving policies and other assistance programs

Energy Contingency Plan	Pricing Measures
Equity considerations (Equity)	- Low degree of equity if there are no assistance programs for the vulnerable groups - Existence of equity if the assistance programs include all the needy and operate efficiently and broadly if the government redistributes income efficiently
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- No need to monitor the controlled prices but need to monitor how the shortages and the rising prices affect each group (differences in income, urbanized setting, and severity of a crisis), how fuel poverty increases, how effectively the assistance programs work, how it impacts each economic sector, etc. - Fuel poverty index can be a triggering mechanism - Barriers are political pressure, political instability, weak institutional capacity that distorts price signals, redistributing income inefficiently, obstructing the laws that prevent fuel price subsidies in the future, etc.
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- High potential for oil saving but the effectiveness of mobility and accessibility and the impact assessments depend on the assistance programs and the available less fuel intensive-travel modes - Particular weather conditions and seasons might lead to less contribution from some less fuel intensive-travel modes; for example, fewer people walk and bike during the rainy season and cold winter; other strategies such as working from home and compressed workweeks needed for substitution

Energy Contingency Plan	Pricing Measures
	- Positive effects on environment and congestion - Other benefits for subsidy removal such as no fuel smuggling, lower government expenditures, etc.

Note: The information originally comes from the articles listed in Table 4.3 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.2 Public Transit Enhancement

From the research articles sampling, 33 of 150 articles presented in Table 4.5 discuss public transit enhancement as a more fuel-efficient travel mode during an oil crisis as well as during normal circumstances. However, there are several barriers to enhancing the use of public transit although one might find that ridership automatically increases when oil prices jump.

Table 4.5 Data Collection for Public Transit Enhancement

Authors, Year	Areas, Methodology
Anderson, 1983	U.S., Experiences
Barker, 1983	U.S. (TX, MN, WI, CA, VA, MD, WA, TN, OR, CO, NY), Experiences
Beirao & Cabral, 2007	Portugal (Porto), In-depth interview
Belk, Painter & Semenik, 1981	U.S. (Salt Lake City), Interviews
Bresson, Dargay, Madre & Pirotte, 2003	England and France, Econometric model
Brunso, 1983a	U.S. (NY, NJ), Telephone interviews with the top government agency and transit personnel

Authors, Year	Areas, Methodology
Brunso, 1983b	U.S., Comments and experiences
Chao, Huang & Jou, 2015	Taiwan, Econometric model
Cox, 1983a	U.S., Experiences
Cox, 1983b	U.S., Experiences
Davis, 1983	U.S., Survey on transit authorities
Grischkat, Hunecke, Bohler & Haustein, 2014	Germany, Mobility diaries and in-depth interview
Guirao, Garcia-Pastor & Lopez-Lambas, 2016	Spain (Madrid), Survey and comparison
Hartgen, Brunso & Neveu, 1983	Several cities in the U.S., Studies and Survey in NY
Hartgen & Neveu, 1980	U.S. (NY) Survey on 1,520 New York residents
Holmgren, 2007	U.S., Australia, and European countries, Meta-regression
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Lane, 2012	U.S., Time series regression
Lee, 1983	Australia, New Zealand, U.K., Netherlands, Experiences and literature
Lin & Du, 2017	China (30 provinces), Probit-logit model, and difference-in-difference (DID) model
Lyons & Chatterjee, 2002	U.K., Survey conducted right after the crisis ended
Morton, Caulfield & Anable, 2016	U.K. (Scotland), Data from Scottish Household Survey and exploratory factor analysis

Authors, Year	Areas, Methodology
Noland, Polak, Bell & Thorpe, 2003	U.K. (London, South East, and North East), Telephone survey after the crisis ended for 2 months
Nordfjaern, Simsekoglu & Rundmo, 2014	Norway, Postal questionnaire and structural equation modeling
Nowak & Savage, 2013	U.S. (Chicago), Econometric model
Rayle, Dai, Chan, Cervero & Shaheen, 2016	U.S. (San Francisco), Intercept survey and comparison with previous taxi surveys
Redman, Friman, Garling & Hartig, 2013	Developed countries, Qualitative systematic review of 74 studies from the 1990s to 2010s
Santos, Behrendt & Teytelboym, 2010	Unspecified area, Literature on policy instruments
Schueftan, 1983	U.S., Studies from DOT based on the interview
Van, Choocharukul & Fujii, 2014	Japan, Thailand, China, Vietnam, Indonesia, the Philippines, Surveys on engineering students and used logit models
Van Malderen, Jourquin, Thomas, Vanoutrive, Verhetsel & Witlox, 2012	Belgium, Data from the home-to-work travel survey and binary choice model
Vance & Peistrup, 2012	Germany, Probit models
Xylia & Silveira, 2017	Sweden, Secondary data, purposefully sampled surveys and in-depth interviews

The research articles in the 1980s provide insightful information about possible problems during a crisis. Most of the recent articles focus on public transit enhancement regardless of whether an oil crisis exists, but they offer more updated information about new types of transportation such as ridesourcing services made possible by smartphones and mass rapid transit (MRT) in emerging markets. Moreover, the articles studying public transit enhancement in a normal situation tend to provide a more sensible solution to sustain public transit ridership behavior after a crisis.

-Public transit ridership increased during a shortage (Noland et al., 2003). A significant amount of people used public transit for the first time during the crisis (Lyons & Chatterjee, 2002). Unlike other saving measures, no matter what the causes of shortages are, public transit enhancement as a way to cope with an energy crisis gained very high support (Belk et al., 1981), and mitigate mobility limitations (IEA, 2005b).

- The measures to encourage the use of transit have limitations in increasing capacity as public transport already is “near capacity, especially during peak hours”, and it can save energy at only “modest” levels (Davis, 1983, p. 92; Cox, 1983a). Moreover, the operator usually does not have enough readily repairable buses (Scheuftan, 1983).

- In addition to the limited buses, adding more buses has several barriers. The obstructions include a lack of trained bus drivers, the need to increase the budget to pay additional or overtime personnel and additional fuel, lack of information for potential riders, low fuel availability, an inadequate amount of equipment and an inadequate number of people who can repair buses (Barker, 1983; Scheuftan, 1983, IEA, 2005b). The need to “hold public hearings, union labor agreements”, “limited flexibility to transfer vehicles among routes” during peak hours, and “technical scheduling complexities to change schedules and manage vehicles and drivers” (Scheuftan, 1983, p. 70; Davis, 1983), and lack of funding (Davis, 1983) are challenges.

- Existing transit might not be able to serve the increasing demand. Thus, private vehicles and school buses might help, but the issues of franchises, insurance, and labor contracts need to be considered in advance (Anderson, 1983).

- Variable work periods and compressed workweeks can smooth the peak period demand for transit, but again it requires preparation and coordination with transit operators and employers (Scheuftan, 1983).

- Plans should prepare to "inform first-time transit riders about the routes and schedules and inform all riders about any changes" during a crisis. Moreover, transit information should be "coordinated with local governments and employers" (Davis, 1983, p. 92). Hindrances of information distribution are unfamiliarity of first-time riders, the constraints of the phone system used, and a lack of trained operators (Schueftan, 1983).

- Policymaker should recognize that transit enhancement alone can contribute little to oil saving (IEA, 2005b; Hartgen & Neveu, 1980; Cox, 1983a), as public transit generally runs at near capacity, especially during peak hours, even during normal circumstances. Several measures should thus be implemented simultaneously. Because significant savings result from fuel-efficient cars, as people want to maintain mobility, the government should offer "packages of actions for different market segments depending on the savings behaviors of each group" (Hartgen & Neveu, 1980, p. 30).

- Involvement from private bus operators at an early stage has great potential in response to an emergency (Cox, 1983b). "Barriers to free entry into transportation by private operators and cooperating agencies" should be removed during emergencies in order to increase flexibility in mobility (Cox, 1983b; Brunso, 1983b, p. 8). Relaxing vehicle insurance provisions might be needed as well (Brunso, 1983b).

- More subsidization may be needed during an emergency. Setting up agreements with bus/van rental companies, tourism companies, and related associations to provide vehicles together with trained drivers and insurance to utilize the "more luxurious" vehicles provided and charge the new and infrequent passengers at a "higher" rate as they might be willing to pay can reduce the increasing burden. This strategy reduces the need for subsidies and generate higher comfort for infrequent riders (Cox, 1983b, p. 99-100).

- Oil price interventions during price shocks have a negative effect on promoting transit use (Chao et al., 2015).

- Households without cars and small households rely on transit for both work and non-work trips. Carpooling is more popular for large households with cars (Hartgen & Neveu, 1980). In addition to user characteristics, lifestyle, situational variables, and the perception on each transportation service can determine mode selection (Beirao & Cabral, 2007).

- Some studies find that the number of persons who ride mass rapid transit (MRT) is more responsive to oil price shocks than bus ridership (Chao et al., 2015; Lane, 2012). Perception of the light rail is considerably more favorable than buses, mainly from private car users' point of view (Beirao & Cabral, 2007).

- Transit operators need to enhance the flexibility of their management by improving information regarding transfers and making all transit information up-to-date in a timely fashion, etc. to the potential riders (Chao et al., 2015).

- The determinants for public transportation demand include vehicle ownership (-), the price of gasoline (+), bus fare (-), and income (-) (inferior goods) (Holmgren, 2007). Besides fares, other relevant variables are reliability, frequency, speed (Redman et al., 2013; Lyons & Chatterjee, 2002), personal perceptions, motivation to use private cars, passenger demographics, individual circumstances, and past experiences with transit services (Redman et al., 2013).

- A U.S. study shows that cross elasticity of public transit (with gasoline prices) is higher at a high gasoline price. Additionally, the cross elasticity in this century is higher than that of the 1970s shocks because of an influence of a media frenzy (Nowak & Savage, 2013).

- In order to encourage transit use, subsidizing transit fares and reducing the fares are methods needed in the case of France and England (Bresson et al., 2003). Some studies find that increases in fuel taxes better increase transit ridership (Vance & Peistrup, 2012), and other push measures such as high parking charges, very limited time for parking, expensive fines for violations, etc. (Lin & Du, 2017) can be used.

- People from various socio-economic cohorts perceive the quality of the transit service differently (Morton et al., 2016, Guirao et al., 2016, Vance & Peistrup, 2012). For example, having dependents in the household tends to reduce the likelihood of ridership (Vance & Peistrup, 2012).

- Attachment to cars, dependence on cars, and car status discourage people from switching to public transit (Beirao & Cabral, 2007). In contrast, public transit riders look at the functional benefits of cars. In other words, for public transit riders, cars are good for nighttime, shopping purposes, and long distance trips (Beirao & Cabral, 2007).

- Advantages of public transportation consist of cost (more sensitive for lower income groups), reduced stress of driving, opportunities to do other activities such as napping and reading, less commute time in case special lanes of transit are available, reduced environmental damages, and opportunities to make conversation with others on the bus (Lyons & Chatterjee, 2002; Beirao & Cabral, 2007). Disadvantages of public transportation are waste of time (Lyons & Chatterjee, 2002; Beirao & Cabral, 2007), crowding, lack of comfort, "lack of control, unreliability, long waiting times, need for transfers, traffic, lack of flexibility, long walking times" (Beirao & Cabral, 2007, p. 482), unavailability of simple-to-understand information (more information about the bus needed, confusing information, change without advanced notice) (Beirao & Cabral, 2007; Grischkat et al., 2014), perceived safety issues (Van Malderen et al., 2012), practical concerns such as weather, carrying large and heavy items, etc. (Lyons & Chatterjee, 2002), and "lack of accessibility" (Grischkat et al., 2014, p. 300).

- To motivate people to use public transit, push and pull measures are necessary. It requires better transit service, a certainty of performed timetables, direct transportation from one place to another place, more accessible and easier to receive information, cost saving, scarcity of parking, and greater comfort. Additionally, advertising campaigns focusing on the contribution to less pollution making public transportation a symbol of altruism and a clean environment (whereas cars would be viewed as negative status symbols) and changing the negative image of public transit through positive experiences are vital (Beirao & Cabral, 2007).

- Policies to encourage more transit use should be tailored toward specifically targeted groups (Beirao & Cabral, 2007; Vance & Peistrup, 2012). Social media promotions via family and friends can increase transit ridership (Nordfjaern, 2014).

- A study of the 6 Asian countries find that social orderliness (aspects such as "environmentally friendly, safe, altruistic, and quiet (Van et al., 2014, p. 39)) needs to be improved in Thailand, China, Vietnam, and Indonesia, while Japan does not have this need. The use of public transportation is low among those developing countries compared with Japan (Van et al., 2014).

- Ridesourcing services with technology utilization like Uber and Lyft do not only replace taxi trips, but they also draw travelers from transit, driving, and non-motorized modes of transportation. Complementary uses for transit such as convenient connections to public transportation, nighttime trips, severe weather conditions, trips with heavy and large items, and so on are also reported (Rayle et al., 2016).

- Environmental concerns are rarely considered among car users and some people think that buses also pollute (Beirao & Cabral, 2007). Moreover, during a shortage in the 1970s, Dutch people accused their government of using fuel-intensive public modes (Lee, 1983). In contrast, the Swedish government has attempted to increase renewable energy in public transportation. "A strong political will, clear programs, goals and strategies for sustainable transport, and flexibility for regions to explore and multiple fuels and technological options" (Xylia & Silveira, 2017, p. 410) have led Sweden to a significant accomplishment.

- To enhance public transit use, a policy should not be limited to public transit, but should integrate across various forms of transportation, government goals, social groups, and government units (Santos et al., 2010).

- An analysis of Public Transit Enhancement is presented in Table 4.6. Limitations of transit capacity, quality of transit, and higher costs should be solved before a crisis starts or at least the government should prepare for agreements and public-private cooperation to be activated and enhanced during an emergency. The strategies can include dedicated bus lanes, fare reductions, increased frequency and reduced wait times, improved connectivity with other transportation modes, and so on.

Table 4.6 Analysis of Public Transit Enhancement

Energy Contingency Plan	Public Transit Enhancement
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Build public transportation infrastructure which connects other travel modes and provides high accessibility for all with proper facilities for disabled, senior citizens, weather, and practical issues - Improve operation and management systems aiming to increase convenience, comfort, rapidity, reliability, coverage, safety, ease of connections, affordability, awareness of the need to respect other passengers sharing transit, cleanliness, etc.

Energy Contingency Plan	Public Transit Enhancement
	- Employ technology to help increase the quality, e.g., GPS, real-time arrival information, smart boards at stations, etc. - Need to reorganize the transit operator system if it is inefficient - Cooperate with other government units to integrate their different government objectives - Set up agreements with bus/van rental companies, tourism companies, and related associations to provide vehicles together with trained drivers, and insurance - Practice emergency preparedness to deal with the higher demand for ridership - Discuss and set agreements with the labor union
Contribution to maintaining mobility (Provide an option to travel under E4 perspectives; better understanding and managing HO, NE, SE, DE increases its contribution)	- Moderate contribution because of limitations of already high ridership during peak hours and capacity; other saving measures and pre-implementation activities are required - Higher ridership during a crisis leads to a perceived lower quality of service if not well-prepared and leads new riders to switch back to private cars after a crisis ends - Higher ridership during an emergency might affect passengers with disabilities and senior citizens - Need to consider the interactions with other saving policies to gain the highest benefit; for example, re-adjust transit schedules to match with the compressed workweek policy

Energy Contingency Plan	Public Transit Enhancement
Public acceptability/ information component and plan updates (Understanding the interactions among HO, NE, SE, DE can increase public acceptance)	- High public acceptance because it requires less fuel per rider while maintaining mobility, but confusion, crowded conditions, and other drawbacks of public transit can lessen public acceptance - Provide information about any changes for existing riders and provide attractive and interactive information based on section 4.1.2.10 for new riders to gain higher acceptance - Employ technology to disseminate the information - Provide specific information for targeted audiences, for example, information about night buses for those who work at night, information about shelters at the bus stop during cold winters and rainy seasons, etc.
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, consider equity, mitigate environmental degradation)	- Contribute small to moderate fuel saving with limitations of infrastructure capacity; as a result, it needs a combination of saving policies to increase the saving potential - Increase transit capacity in response to fuel prices, but the ability depends on the pre-implementation activities - Need to use fuel-efficient vehicles and efficient route planning to save more fuel - Take time to adjust transit system, train drivers, increase transit capacity, etc. depending on the pre-implementation activities
Funding sources (Economy and Equity)	- Oil taxes and other taxes - Require laws to ensure funding because of the higher cost of fuels and increased transit capacity

Energy Contingency Plan	Public Transit Enhancement
	- Reduced fare can increase ridership, but transit operators might have a greater burden - Reduce funding burdens by cooperation with the private sector such as company subsidization of public transit fares and passes, other financial incentives for transit riders, etc.
Equity considerations (Equity)	- High level of equity if fares are affordable and transit is highly accessible; hence, the government needs to ensure these factors in the pre-implementation process - Crowded conditions during a crisis can obstruct transit riding for children, senior citizens, disabled citizens, etc.
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- Need to monitor fuel prices and ridership; fuel price increases can trigger a change in transit systems and activate the agreements and cooperation - Monitor and cooperate with other government units, transit operators, and employers; for example, peak hours will change if the government implements compressed workweeks; higher transit capacity is needed if the government enforces driving bans - Barriers to free entry in transportation can obstruct competition and improvement, and make several agreements harder to attain - Other barriers such as the relationship with the labor union, lack of trained bus drivers, lack of trained transit staff, higher costs, institutional barriers for connectivity with other modes of transportation, etc.

Energy Contingency Plan	Public Transit Enhancement
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- Moderate effectiveness with limitations; it needs to implement other saving policies at the same time; considering synergistic effects with other saving policies such as maintaining high fuel prices, driving restrictions, encouraging bicycling and shared rides, etc. to raise its effectiveness - Less effectiveness in rural areas or the areas that do not have good transit system available; as a result, other measures are needed for those areas - Positive impacts as it can save fuels, maintain mobility, and mitigate air pollution; however, using old and less fuel-efficient buses lessens the benefits (because of higher pollution and accidents) - Strike, fears of disease outbreak, and fears of terrorism can make the effectiveness decline; for example, oil refinery explosions after a series of terrorist attacks in public areas or involving public transit

Note: The information originally comes from the articles listed in Table 4.5 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.3 Carpooling

Carpooling can be categorized into 3 types, “acquaintance-based or fampooling, organization-based, and ad hoc or casual ridesharing or slugging” (Zolnik, 2015, p. 48). Carpooling or ridesharing offers a less fuel-intensive option and travel cost reductions.

The research sample reviewed for carpooling policy consists of 25 articles. There are shown in Table 4.7.

Table 4.7 Data Collection for Carpooling

Authors, Year	Areas, Methodology
Barker, 1983	U.S. (TX, MN, WI, CA, VA, MD, WA, TN, OR, CO, NY), Experiences
Bento, Huges & Kaffine, 2013	U.S. (Los Angeles), Weekly traffic flow and equilibrium sorting model
Berman & Radow, 1997	U.S., Available policies and lessons learned
Bicocchi & Mamei, 2014	Italy, Experiments by using the Google Latitude data and mobility data
Brunso, 1983a	U.S. (NY, NJ), Telephone interviews with the top government agency and transit personnel
Cox, 1983b	U.S., Experiences
Dare, 1983	U.S. (rural areas), Data and survey on local government
Delhomme & Gheorghiu, 2016	France, Online survey
Friginal, Gambs, Guiochet & Killijian, 2014	France, Survey and dynamic carpooling systems
Furuhata, Dessouky, Ordonez, Brunet, Wang & Koenig, 2013	U.S., Literature reviewed and evidence regarding ridesharing
Grischkat, Hunecke, Bohler & Haustein, 2014	Germany, Mobility diaries and in-depth interview
Guidotti, Nanni, Rinzivillo, Pedreschi & Giannotti, 2017	Italy, Experiments and network analytics

Authors, Year	Areas, Methodology
Hartgen, Brunso & Neveu, 1983	Several cities in the U.S., Studies and Survey in NY
Hartgen & Neveu, 1980	U.S. (NY) Survey on 1,520 New York residents
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Jacobson & King, 2009	U.S., Mathematical model
Noland, Polak, Bell & Thorpe, 2003	U.K. (London, South East, and North East), Telephone survey after the crisis ended for 2 months
Schueftan, 1983	U.S., Studies from DOT based on the interview
Seyedabrishami, Mamdoohi, Barzegar & Hasanpour, 2012	Iran (Tehran), Stated preferences survey and logit model
Su & Zhou, 2012	U.S. (Washington), Washington State Commute Trip Reduction dataset and nested logit model
Teal, 1987	U.S., Analysis of 1977-1978 Nationwide Personal Transportation Survey
Vanoutrive, Van De Vijver, Van Malderen, Jourquin, Thomas, Verhetsel & Witlox, 2012	Belgium, Exploratory spatial data analysis and a multilevel regression model
Wakeford, 2013	South Africa, Literatures for qualitative analysis
Wang, 2011	China, Studies reviewed and statistic data for analysis
Zolnik, 2015	U.S., Generalized linear multilevel model

This section discusses the barriers to implementing carpooling policies and the interaction with other saving policies. In addition to the barriers mentioned in articles written 2-3 decades ago, more recent articles address the opportunities and challenging issues of using technology and environmental awareness.

- Challenging issues of carpooling programs during a crisis are “match-list turnaround time”, “timely delivery of new vans” during a period of high demand, and finding fuel for the carpool vehicles (Schueftan, 1983, p. 70). Others barriers, in general, are “high crime rates and a threat of hijacking” (Wakeford, 2013, p. 42) in some areas, the desire for privacy and aversion to socialize with others (Zolnik, 2015), and the distance and additional time to pick additional carpoolers (Jacobson & King, 2009). Carpooling websites (Seyedabrishami et al., 2012) and mobile technology can reduce the matching problem (Furuhata et al., 2013; Wang, 2011; Wakeford, 2013; Zolnik, 2015; Guidotti et al., 2017; Bicocchi & Mamei, 2014; Friginal et al., 2014).

- Transit should play a more important role in cities, while community and employer-based carpooling, greater fuel efficiency, car literature, and trip planning become more important in rural areas (Hartgen et al., 1983; Dare, 1983). Carpooling programs cannot only reduce fuel consumption during a supply disruption, but it can also offer a travel option during rail or bus strikes (Brunso, 1983a).

- Public-private cooperation, coordinating with employers and a third party, is vital for carpooling (Cox, 1983b), but they need “advance agreements” as it is done under contract (Brunso, 1983a, p. 59). To encourage carpooling, employers need to ensure that their employees understand the promotional programs, show the intention to support the programs from the executive level, and take various packages of strategies into account (Su & Zhou, 2012).

- The several carpooling strategies can be done. Complementary car washes for participated carpools, reduced fares on public transit services, special discounts at retailers to encourage more carpooling, extensive networks, an increase in the cost for solo drivers also promote carpooling. Some of these measures can reduce government's financial burdens (IEA, 2005b).

- The government should offer a "package of actions for different market segments depending on the savings behaviors of each group" (Hartgen & Neveu, 1980, p. 30). For example, carpooling is more popular for larger households and those with cars (Hartgen & Neveu, 1980).

- A survey after the 2000 fuel shortage in the U.K. found that traveling as a passenger increased by 60% (Noland et al., 2003). However, policymakers should prepare for the side effects of carpooling policies. Carpooling often draws people from public transit when HOV lanes or carpooling programs are created during normal circumstances (Wang, 2011; IEA, 2005b) but during an emergency it tends to come from solo drivers (IEA, 2005b) and could mitigate overcrowded conditions in public transit. However, transit is preferable to carpooling if transit quality is high (Teal, 1987). Other problems are that legitimized voluntary carpooling can be used as a way to get around the licensing required to operate taxis and it can also impact safety (Wang, 2011). Additionally, policymakers should not overlook interaction effects among saving policies, for example, fuel price subsidies discourage carpooling, and flexible work time makes carpools more difficult (Berman & Radow, 1997).

- Based on a study in Los Angeles, the traffic flow in carpool lanes (HOV) immediately falls, but then increases again over time. This is because drivers in an HOV lane are more sensitive to fuel price movements by switching to other alternative modes like public transit. (Bento et al., 2013). Improved HOV infrastructure can reduce the social costs of car uses (Bento et al., 2013, Zolnik, 2015).

- There are several reasons why people carpool and they vary for each community and lifestyle. People carpool because of a high travel cost, the low number of vehicles per household, the existence of several workers in the family (Teal, 1987), considerations involving comfort, reductions in air pollution, time saving (Delhomme & Gheorghiu, 2016), rising oil prices (Wang, 2011; Zolnik, 2015), and high costs of vehicle use (Wang, 2011). In Belgium, working or living at a relatively inaccessible location, poor public transportation (Vanoutrive et al., 2012), “regular work schedules, and a small number of employees at a site” increase the likelihood of carpooling (Vanoutrive et al., 2012, p. 85). Better HOV facilities (Zolnik, 2015; Su & Zhou, 2012) increase likelihood of ridesharing.

- Carpooling with family members or someone they know is more favorable than ridesharing and organized carpooling (Grischkat et al., 2014). However, a study from Iran finds that about 44% of the respondents want to carpool regardless of whether they know each other (Seyedabrishami et al., 2012).

- Different carpooling arrangements offer different advantages and disadvantages. Carpooling organized by governments and/or private firms proves cost-effective, but it is not flexible. Flexible carpooling does not require established schedules for matching participants, but calls for a considerable number of participants (Furuhata et al., 2013). The Internet-based matching agencies can improve the system (Furuhata et al., 2013). The challenges of this type of carpooling are the design of attractive mechanisms and the need for trust among travelers (Furuhata et al., 2013; Bicocchi & Mamei, 2014; Friginal et al., 2014. Private information issues as the riders having to provide personal information (Furuhata et al., 2013; Bicocchi & Mamei, 2014; Friginal et al., 2014), and ambiguity about legal issues of car sharing services and Internet advertising (Furuhata et al., 2013) create important issues.

- Carpooling is found to be the best contribution to trip reduction in the U.S. as it keeps solo driving characteristics. In order to make carpooling an attractive alternative, other measures such as raising parking charges, high road toll fees, etc. are needed (Jacobson & King, 2009). In other words, both push and pull measures are necessary.

- In addition to push and pull measures, "positive spillover effects" should be designed to fit with the community. (Delhomme & Gheorghiu, 2016, p. 10). Environmentally friendly behavior to increase carpooling and targeting interested group with the right information women are useful (Delhomme & Gheorghiu, 2016

- An analysis of carpooling programs is found in Table 4.8. Carpooling increases mobility and reduces fuel consumption at the same time. To increase its effectiveness, the program mainly requires cooperation among public and private sectors and the development of information technology.

Table 4.8 Analysis of Carpooling

Energy Contingency Plan	Carpooling
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Use technology to match riders and drivers on the Internet base with minimized risks of private information issues and other concerns - Set up agreement and cooperation with the Internet-based matching agencies, car/van/bus rental companies, tourism companies, etc. together with employers to provide carpooling programs for employees - Prepare incentives such as tax exemptions, tax credits, etc. for those who participate - Practice preparedness within the private sector to use the matching technology, set routes, and generate a sign-up program
Contribution to maintaining mobility (Provide an option to travel under E4 perspectives; better understanding and managing HO, NE, SE, DE increases its contribution)	- Moderate to high contribution as it can serve those who do not have transit access and those who have dependents or big families; however, it depends on the effectiveness of the matching system, public information, and other factors such as social norms, crime rates, etc. - Play a significant role in rural areas and a good travel option in urban areas

Energy Contingency Plan	Carpooling
Public acceptability/ information component and plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- Moderate to high public acceptance depending on the factors mentioned in contribution to maintaining mobility - Provide information about costs if driving alone, available carpooling programs and routes, etc. by using public information strategies stated in section 4.1.2.10 and use tailored information based on urban setting, income, etc.; for example, information about cost saving might be more focused for the poor while inducing a warm glow and providing praise might be more focused for the rich
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, consider equity, mitigate environmental degradation)	- Moderate to large fuel savings depending on how comprehensive carpooling programs are and how well the programs run, but commuters have more options than transit enhancement alone - Technology with good privacy protection, trust, and safety can increase carpooling - Take time to match carpoolers especially when technology is not utilized
Funding sources (Economy, equity)	- Oil taxes and other taxes - Private funding sources or combination of public and private sources such as benefits provided by employers, special discounts from retailers, etc.
Equity considerations (Equity)	- Equity is improved, especially in the areas with poor transit access - Need to ensure that people can access the Internet-based carpooling system or traditional carpooling sign-up program

Energy Contingency Plan	Carpooling
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- Use fuel prices or fuel poverty as a trigger - Screen and monitor private agencies participating in the programs, and cooperate with employers - Monitor to deal with side effects such as illegal taxis, switching from transit ridership and non-motorized modes to carpooling and ridesourcing, private information protection, and so on - Need cooperation among public and private sectors - Barriers regarding information protection
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- Effectiveness is higher if more employers and employees participate, and if matching systems and sign-up programs can be implemented quickly - Benefits for energy saving, mobility, traffic congestion, environment

Note: The information originally comes from the articles listed in Table 4.7 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.4 Telecommuting

Telecommuting policy can be implemented to save gasoline, but it involves a high level of organization at work as well as a high work-life balance. This section utilizes 16 articles to explore the barriers and opportunities of telecommuting. The reviewed articles are listed in Table 4.9.

Table 4.9 Data Collection for Telecommuting

Authors, Year	Areas, Methodology
Aguilera, Lethiais, Rallet & Proulhac, 2016	France and Data from surveys in 2008 by National Survey on Transport and qualitative analysis
Caulfield, 2015	Ireland (Dublin), Data from the 2011 census and multinomial logit regression
Choo & Mokhtarian, 2007	U.S., Conceptual model and structural model
Dutcher, 2012	U.S. (Florida), Experiment (in the lab and out of the lab) and regressions
Fu, Kelly, Clinch & King, 2012	Ireland, Data from the Irish Place of Work Census 2006 and logit model
Hamsa, Jaff, Ibrahim, Mohamed & Zahari, 2016	Malaysia (Kuala Lumpur), Survey on female employees and a binary logistic regression model
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Mitomo & Jitsuzumi, 1999	Japan (Tokyo), Railway-commuter disutility function to evaluate congestion reduction
Neufeld & Fang, 2005	Canada, In-depth interviews and surveys
Noland, Polak, Bell & Thorpe, 2003	U.K. (London, South East, and North East), Telephone survey after the crisis ended for 2 months
Pearce II, 2009	U.S., Qualitative analysis of successful practices
Perez, Sanchez & Carnicer, 2002	Spain (Aragon), Mail survey from 157 HR managers
Peters, Tijdens & Wetzels, 2004	Netherlands, Multivariate analyses
Rhee, 2008	Unspecified area, Spatial equilibrium model

Authors, Year	Areas, Methodology
Roder & Nagel, 2014	Germany (Berlin), Simple analytical model and simulation model
Yap & Tng, 1990	Singapore, Survey of 459 female computer professionals

Unlike public transportation enhancement and carpooling used during the 1970s crises, telecommuting has become more feasible recently now that more advanced technology is available. However, concerns among employers and employees and needed infrastructure are challenging issues that policymakers have to understand and work with as the oil saving policy should reduce oil consumption but not generate work-life problems.

- Some studies argue that while in the short term, telecommuting can substitute or cut back travel demand, in the long term working from home can create new or different travel demands (Choo & Mokhtarian, 2007). People might “relocate to live further from their workplaces” (IEA, 2005b, p. 80), and they might increase non-work trips from home during the day (Rhee, 2008; IEA, 2005b). Besides, telecommuting lessens energy uses in transportation, but it raises energy uses at home while not considerably decreasing energy demand at the workplace (Roder & Nagel, 2014).

- In addition to oil supply disruptions, telecommuting can be used for other emergencies such as dangerous air pollution, transit strikes, (IEA, 2005b), “threats of terrorism, civil disturbances, natural disasters” (Pearce II, 2009, p. 18), influenza outbreaks, highway disruptions and so on, (Pearce II, 2009).

- The Government needs to have large companies sign up for a telecommuting program, and ensure the necessary infrastructure to work from home such as computer and Internet access, especially urban workers. Preparing by designating which employees will participate and what situations qualify as a trigger is essential (IEA, 2005b).

- Working from home is suitable only for a limited number of intellectual professionals (Aguilera et al., 2016; Hamsa et al., 2016). The concerns over this strategy consist of management of employees and feeling a necessity of having all staff members at the workplace for facilitated communication (IEA, 2005b), the need to revise work organization, the impact on productivity, and investment in technology and infrastructure (Aguilera et al., 2016; Perez et al., 2002). Other concerns are fragmented social interaction at the organization (Pearce II, 2009) and "security and information protection" (Pearce II, 2009, p. 23).

- Workers have concerns about "isolation while working at home" (Hamsa et al., 2016, p. 417). Although 84% of the teleworkers in France reduce travel demand when they work at home, only 12% feel that teleworking improves their work-life balance (Aguilera et al., 2016). Some find that time saved from commuting to office is likely to be spent on more work at home, rather than leisure (Rhee, 2008). About 35% of Malaysian female employees who can telework do not want to do so (Hamsa et al., 2016), and only 22% of teleworkers feel that work at home enhance productivity (Aguilera et al., 2016). Accessibility of resources, suitability of tasks for work at home, management of role conflicts (mom vs. worker), career development, and questions of fairness to all employees (Yap & Tng, 1990) lessen willingness to telecommute. Most of the respondents who are in favor of telecommuting in Singapore want to maintain their "full-time employment status" while working at home 1-3 days a week (Yap & Tng, 1990, p. 232).

- The factors that support working from home are the suitability of certain jobs, morning traffic congestion, higher utilization of smartphones (Hamsa et al., 2016), better information communication technology (Mitomo & Jitsuzumi, 1999), living in places with higher levels of people teleworking or locating in a wealthier neighborhood with poor transit accessibility (Caulfield, 2015). Other factors are the improved Internet access (Fu et al., 2012), and being an employed parent with young children (Pearce II, 2009; Peters et al., 2004). However, having too many children discourages telecommuting. Being married, having more education (Fu et al., 2012), environmental sustainability, cutbacks in operating costs (Pearce II, 2009), being in a supervisory position, working in firms with several business sites, working in firms with flatter organization, and being a long-distance commuter (Peters et al., 2004) also increases the likelihood of telecommuting.

- The preference for telecommuting can change, and the temporary desire depends on the particular life events because workers can take advantage of the ability to work and look after their family simultaneously and elevate the opportunity for independent time management (Yap & Tng, 1990).

- Another study finds that workers who use "more information and communication technologies" (Perez et al., 2002, p. 782) and who involve creative tasks (Dutcher, 2012) are likely to find benefits in telecommuting.

- To enhance productivity for teleworkers, creating positive attitudes through strong social interaction, a calm environment, and adequacy of important resources is vital (Neufeld & Fang, 2005). Besides communication and attitudes improvements, telecommuting enhancement needs to ensure good quality and affordable childcare (Yap & Tng, 1990).

- An analysis of telecommuting or work at home is presented in Table 4.10. The main issues of this saving policy are involvement from the private sector, investment in infrastructure, and the willingness of employers and employees to change. However, the related concerns are relatively small during a short-time crisis.

Table 4.10 Analysis of Telecommuting

Energy Contingency Plan	Telecommuting
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Cooperate with employers to sign up employees for a telecommuting program and set up the needed infrastructure to work from home - Adjust regulations to support the work at home program during an emergency such as minimum infrastructure needed, rights of employers and employees, etc. - Perform preparedness exercises with large organizations on a more detail level such as who can work from home and how to maintain their productivity and work-life balance
Contribution to maintaining mobility	- Do not need mobility but can maintain economic activities; however, contribution depends on the

Energy Contingency Plan	Telecommuting
(Provide an opportunity for others to travel; the work-trip reduction policy can meet E4 perspectives; better understanding and managing HO, NE, SE, DE increases its contribution)	number of participants and days they can work from home - Provide indirect mobility benefits for others such as less crowded transit and more fuel available for other trips
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- High public acceptance as workers can save time and cost of transportation; however, fairness among those who work at office and those who work at home is important - Need cooperation and updates from private sector - Focus on altruistic outcomes that employers can provide for their employees and society during an emergency, information about losses if they do not do so, or do not invest in the infrastructure - Provide information about successful practices by other companies in similar business
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, mitigate environmental degradation)	- Large ability to save fuel if several workers participate and infrastructure is available - Small rebound effect from electricity consumed at home and non-work trips - Take significant time to implement as it needs cooperation from private sector
Funding sources (Economy, equity)	- Private funding but need some incentives for participating employers - Convince employers to invest in telecommuting plan and incorporate the plan for fuel saving with

Energy Contingency Plan	Telecommuting
	the plan in response to other events (such as influenza outbreaks, terrorist attacks, civil disorders, natural disasters and so on) for their own benefit
Equity considerations (Equity)	- Can be questioned because some tasks cannot be done via telecommuting and higher positions tend to be able to do so, because the poor might not be able to invest in the Internet and computers, and because rural workers might not be able to access to the Internet - Can be questioned between those who work at office and those who work from home
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- Early triggering is needed as it takes time to implement and cooperate with private sector - Update how much fuels saved, benefits and concerns from employers and employees' views - Institutional barriers as some employers and employees concerned about organizational changes, increasing costs, etc.
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- Large effectiveness due to the elimination of work trip - Benefits based on energy, economy and environment perspectives - Equity and work-life balance can be questioned if the plan is not well managed, but during an emergency, the problem should be minimized, and it

Energy Contingency Plan	Telecommuting
	might require telecommuting 1-3 days a week, not 5 days a week

Note: The information originally comes from the articles listed in Table 4.9 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.5 Compressed Workweeks

Compressed work schedules can diminish work trips (Hung, 1996; IEA, 2005b) With limited studies, this section employs 11 articles, and focuses on the compressed workweek, not flexible work schedules which do not diminish the number of work trip. The reviewed articles are shown in Table 4.11. Similar to telecommuting, the policy should not only pay attention to energy and transportation effects, but also requires the involvement and consideration of the effects on employers and employees.

Table 4.11 Data Collection for Compressed Workweeks

Authors, Year	Areas, Methodology
Barker, 1983	U.S. (TX, MN, WI, CA, VA, MD, WA, TN, OR, CO, NY), Experiences
Duchon & Smith, 1993	Developed countries, Laboratory studies and field studies
Duchon, Smith, Keran & Koehler, 1997	Canada, Psychophysiological approach experiment and ANOVA analysis
Ho & Stewart, 1992	U.S. (Los Angeles), Data from a survey conducted before and 6 months after the measure 4/40

Authors, Year	Areas, Methodology
Hung, 1996	Developed countries, Literature and some calculation
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Keran, Duchon & Smith, 1994	U.S., Experiment with 28 underground metal mine workers ANOVA analysis
Milia, 1998	Australia, Experiment on electricians at coal and ANOVA analysis
Paley, Price & Tepas, 1998	U.S., Data collected from 24 firefighters
Schueftan, 1983	U.S., Studies from DOT based on the interview
Sundo & Fujii, 2005	Philippines, Survey of university employees after implementing compressed working week scheme (4/40)

- Compressed workweeks can smooth peak period demand for transit, but they require preparation and cooperation with transit operators (Schueftan, 1983) and employers (Schueftan, 1983; Barker, 1983).

- Although there might be an increase in non-work trips during the day off, it should be negligible during an emergency (IEA, 2005b). Moreover, some of the families need to tighten their budgets and do housework; as a result, a rise in non-work trips is smaller than a cutback in work trips (Hung, 1996).

- The side effect that policymakers should be prepared for is trip redistribution. A study finds that the trips during workdays are "redistributed to the day off" (Ho & Stewart, 1992, p. 28). Additionally, the peak hours are switched, and the narrowed peak hours can affect traffic congestion. However, workers are less likely to run errands before and after work during the long hour workday (Ho & Stewart, 1992). Those who have responsibilities involving other family members are likely to maintain the number of trips generated during the week while those who live alone have more ability to reduce trips (Ho & Stewart, 1992). Commuting times based on the measure for public employees fall considerably. The workers who usually depart early do not significantly alter their commuting schedule in the morning and those who usually work extended hours do not work more hours than usual (Sundo & Fujii, 2005).

- Compressed workweeks can make carpooling more difficult (Hung, 1996). However, carpooling arrangements regarding working schedules and off-days can mitigate the complication (Hung, 1996).

- Advantages of compressed workweeks include a preference by workers (Hung, 1996; Duchon et al., 1997; Paley et al., 1998; Duchon & Smith, 1993) as they have the long weekends, less commuting cost and time, and so on (Hung, 1996). Compressed workweeks can benefit firms with "a reduction in turnover, absenteeism, overtime, requests for days-off, and tardiness" (Hung, 1996, p. 17). One study also finds that workers with compressed workweeks sleep better and experience improved moods (Duchon et al., 1997).

- Challenging issues of compressed workweeks are inflexibility due to other commitments, which may prohibit switching schedules, the need for legislative changes during a crisis (IEA, 2005b), increased use of utilities during the extended hours, and "unavailability of key personnel" during an off day (Hung, 1996, p. 18). Fatigue is a concern, and safety and performance may deteriorate in some industries (Duchon &

Smith, 1993). However, extra fatigue for the extended day is not always the case because of workers' enthusiasm for the extra holiday (Hung, 1996). Another study did not find an obvious difference between regular hours and longer hours for workers in different ages, except for their performance when they start working each week and when they are about to finish working each day (Keran et al., 1994). Total sleep time is not found to modify significantly in total, but the distribution of sleep adjusts, especially during night shifts and off days (Milia, 1998).

- Although some evidence does not show a negative impact from the extended work shift on the workers (Paley et al., 1998; Duchon et al., 1997), several researchers recommend measures that lessen fatigue, error, and accidents such as "taking breaks, and doing mentally challenging or light physical tasks" (Duchon et al., 1997, p. 48). Policymakers should not overlook the general problems that could be found from shift work and night work (Paley et at., 1998) and should take into consideration those tasks for which safety is a main concern. Moreover, "special efforts to create safe working conditions" (Duchon & Smith, 1993, p. 48) should come as a part of the package of extended workday policies (Duchon & Smith, 1993).

- Transferring information, offering pecuniary incentives, and providing technical support for employers can be considered to encourage the adoption of the compressed work schedule measures (IEA, 2005b). "Increasing family time and boosting local tourism" (Sundo & Fujii, 2005, p. 838) are positive side effects. Thus, policymakers should also consider the effects on employees' lifestyles in order to gain a positive public response (Sundo & Fujii, 2005), instead of attempting to reduce oil demand only.

- An analysis of compressed workweeks is presented in Table 4.12. Some studies express concerns about health, safety, and productivity, but several studies find that compressed workweeks are favorable. Good preparation such as cooperation with private sector, traffic police, transit operators and regulation adjustments are required to implement the policy promptly and successfully.

Table 4.12 Analysis of Compressed Workweeks

Energy Contingency Plan	Compressed Workweeks
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Cooperate with employers to adjust working schedules and set up a plan that is ready to be used - Cooperate with transit operators and traffic police to manage all changes required if a compressed workweek is put into effect - Draft contingency laws that allow a longer workday during an emergency and require standards and guidelines to ensure healthy conditions for the workers
Contribution to maintaining mobility (Provide an opportunity for others to travel; the work-trip reduction policy can meet E4 perspectives; better understanding and managing HO, NE, SE, DE increases its contribution)	- Work-trip reduction (by 1/7 or 1/14) leads to more fuel saved and more transit space available for others; the contribution becomes higher if more employers and employees can participate - Several workers can participate if employers participate; however, it can make carpooling, sending children to school, and so on more difficult; thus the program should prepare for these issues

Energy Contingency Plan	Compressed Workweeks
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- Higher preference from workers since they have a long weekend and save costs and fuel - Less acceptance if there are insufficient travel options available during extended morning and evening hours, and if there is insufficient care about workers' health, especially the tasks for which safety is a major concern - Provide public information to encourage employers and employees to participate based on section 4.1.2.10; for example, set goals to reduce work trip generation and compare with other companies
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, mitigate environmental degradation)	- Reduce fuel consumption by 1/7 or 1/14, quite large contribution if significant amounts of employees participate - Small rebound effect during an emergency on the off-day or weekend; using technology such as online shopping and online payment can reduce errands and non-work trips - Take time to cooperate with private sector
Funding sources (Economy, equity)	- Private sources
Equity considerations (Equity)	- High degree of equity since several workers per company can participate - Equity is lessened if health and safety issues are not addressed - Some positions and some workers with dependents might not be able to participate

Energy Contingency Plan	Compressed Workweeks
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- The policy can start at an early stage as it is low in cost, but needs cooperation from private sector - Need to monitor health and safety condition; special efforts to generate safe working conditions should come as part of the package of an extended workday policy - Monitor rebound effects of oil saving, redistributed traffic, non-work trips during long weekends and off days, as well as the impact on sleep and other health issues - Shorter daylight period might discourage commuters from walking and biking during early morning and late evening
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- High effectiveness as workers prefer long weekends and it can save fuel by 1/7 or 1/14 - Minor negative impacts such as health, safety, fairness for some work positions - Positive impacts on energy, economy, equity, and environment; other benefits are having more time with family during the long weekend, increased tourism, less traffic congestion

Note: The information originally comes from the articles listed in Table 4.11 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.6 Rationing

Allocation controls used in the 1970s were terminated in the next decade in the U.S. and several developed countries, and the industry supported the free-market approach and contingency plans based on the free-market approach (Anderson, 1983; Lee-Gosselin, 2010) as rationing and allocation controls create several problems. Federal regulation and mismanagement are blamed for gasoline shortages in the 1970s while supply disruption is a minor cause (Difiglio, 1984). Thus, governments should "let the marketplace make allocation decisions" (Winkler, 1983, p. 53). In addition to price allocation, several countries create mechanisms to protect themselves from a serious shortage. In other words, the U.S. is unlikely to implement an oil-rationing program during a shortage when the country is insured by the strategic petroleum reserves. Recent studies on rationing policies are scarce; most of the 15 articles used in this section were written before the year 2000. Although the resources are old, they provide valuable information for policymakers if it is necessary to implement these measures again regardless of fuel types. The reviewed articles are listed in Table 4.13.

Table 4.13 Data Collection for Rationing

Authors, Year	Areas, Methodology
Anderson, 1983	U.S., Experiences
Belk, Painter & Semenik, 1981	U.S. (Salt Lake City), Interviews
Bezdek & Taylor, 1981	U.S., Qualitative evaluation by using 4 criteria
Coates, 2016	U.S., Qualitative analysis

Authors, Year	Areas, Methodology
Daskin, Shladover & Sobel, 1976	U.S., Mathematical queuing model
Difiglio, 1984	U.S., Economic demand and supply theory to explain the impact
Hanafizadeh, Navardi & Soofi, 2010	Iran (Tehran), Survey on 2000 car and light pickup truck drivers and inferential analyses
Horowitz, 1982	U.S. (Washington D.C.), Disaggregate travel demand models and sensitivity tests
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Kemp, 1996	New Zealand, 4 questionnaires on students and non-students
Lee, 1983	Australia, New Zealand, U.K., Netherlands, Experiences and literature
Lee-Gosselin, 2010	U.S., Canada, Literatures and shortage simulation
Phillips, 1945	U.S., Rationing experiences of general goods
Thorpe, 2007	U.K., Descriptive analysis
Winkler, 1983	U.S., Experiences

- Rationing policies were often enforced with driving restrictions. The petroleum refinery shutdown in South Australia was coped with restrictions and ration allocations. A maximum quantity of fuel that could be purchased, the ban on all vehicles with some exceptions, and coupon rationing based on registered vehicles in particular areas were imposed (Lee, 1983).

- Rationing policies have been proposed in several countries during a crisis but were not actually imposed. The U.K. plans to implement coupon rationing when there is a 20% shortage with at least a 6-month expectation of shortfall (Lee, 1983). A survey in the Netherlands indicates that rationing should be used for a 30% shortfall situation, and several of the demand restraint measures will need significant explanation for public acceptance (Lee, 1983). In other words, it is recommended using the measure as a last resort since it is likely to incur higher social costs than voluntary measures (IEA, 2005b; Lee-Gosselin, 2010).

- Rationing becomes more favorable if people perceive it is fair and used at the right time (Belk et al., 1981). Also, rationing is more acceptable when scarcity and profit-making from shortages are perceived by consumers (Kemp, 1996). However, rationing should not be limited to only the time of scarcity but should be fairly used to “address minimum access to ample resources” (Coates, 2016, p. 117).

- During a shortage, the long line effect which appears as panic makes consumers refill their tanks more frequently and try to keep their tanks full (Daskin et al., 1976). Moreover, reduced service hours and closures on particular days during the 1974 crisis led to an increase in long queues (Daskin et al., 1976).

- There are several rationing methods: odd-even strategy, maximum purchasing, minimum purchasing, purchase range, and coupon rationing. Coupon rationing itself has different implementations in details such as whether the coupon can be traded on the white market or not, whether price or quantity is fixed and so on.

- “Price and allocation controls” during an emergency require rationing (Difiglio, 1984, p. 216) because “those controls cause shortages” and long queues at gas stations (Difiglio, 1984, p. 216). Coupon rationing provides better equity, reduces panic buying, and encourages more savings simultaneously. However, low political support and adverse effects are shortcomings (Daskin et al., 1976).

- Gasoline can be rationed using transferrable or non-transferable coupons. The latter type is likely to be illegally transferred (Difiglio, 1984; Horowitz, 1982) because some consumers want to drive more than their coupon allotment while some consumers want to drive less. The former type of coupon creates fewer problems than the latter (Difiglio, 1984). The traditional restricted coupon allocation is likely to cause high-income households to cut back their trips dramatically but does not cause low-income households to curtail their travel because they receive more coupons more than they need (Horowitz, 1982). In the transferrable coupon scenario, low-income households tend to make the large conservation in gasoline consumption while high-income households do not contribute much (Horowitz, 1982). The income transfer occurs as they purchase coupon from the poor (Horowitz, 1982).

- Transferrable coupon rationing can be done through fixed quantities or fixed prices, but fixed price rationing creates fewer negative impacts than fixed quantity rationing because it is easier to know the gasoline prices than to estimate the quantity. However, rationing tends to be unsuccessful because of managerial difficulties and high transaction costs (Difiglio, 1984).

- "Gasoline rationing with a fixed allocation of coupons and price controls (fixed quantity rationing)" (Difiglio, 1984, p. 220) requires issuance of the coupon for available gasoline. However, the government tends to allocate too little fuel to some places and too much to others at a particular time because people change their behavior during a crisis

(Winkler, 1983). Too many coupons lead to long queues while too few coupons limit mobility (Difiglio, 1984). It generates income transfer "from those who value their time more" (Bezdek & Taylor, 1981, p. 1360). However, it cannot ensure fairness as, in the past, some will feel that "they are not being treated fairly" (Bezdek & Taylor, 1981, p. 1360). The practical problems are the burden on industry to report information to the government, high government workforce and administrative costs and so on (Bezdek & Taylor, 1981).

- "Gasoline rationing with government sales and purchases at a determined price (fixed price rationing)" (Difiglio, 1984, 1984, p. 220) does not require the government to set the quantity but requires the government to set the price. An inaccuracy of price-setting can lead to the income redistribution between oil consumers and producers (Difiglio, 1984). It can curb price rises and allot the coupons based on registered vehicles (Bezdek & Taylor, 1981). The practical problems include the needs to "print, disperse, transfer and ultimately return coupons" (Bezdek & Taylor, 1981, 1361), "administrative costs and time" (Bezdek & Taylor, 1981, 1361).

- The tradable coupon can be allocated based on registered drivers or licensed vehicles. Although rationing based one licensed vehicles tends to benefit the rich (Difiglio, 1984), the U.S. Department of Energy claims that the vehicles-based system is preferred because of its faster implementation, more sensible reflection to real demand, and the legalized sale of vehicle owners' rationing (Lee-Gosselin, 2010).

- Sprung rationing or preannounced rationing can be selected depending on each situation. If the government does not act fast at the beginning, preannounced ration might be preferred (Phillips, 1945), but if the public "fail to declare stocks on hand" (Phillips, 1945, p. 14), sprung rationing might then be the better option

- Lack of information during an emergency makes the government work ineffectively (Winkler, 1983). A recent rationing situation in Iran indicates that a considerable unavailability of data and information leads to inaccurate analysis (Hanafizadeh et al., 2010).

- Rationing policies encounter several problems. The experience from Australia in 1981 indicates significant problems such as long lines at gasoline stations and critical communication issues (Lee, 1983). Allocation to a top priority list can create serious problems such as difficulties in "defining priorities" and "delays" for those who are not on the list but need to travel (Anderson, 1983, p. 21). The experience from the U.S. in gasoline allocation shows that changes in the allocation guidelines every week make it hard to understand for industry and officials (Winkler, 1983). When preparing for rationing in the U.K. in 1967, government officials had difficulty deciding when to impose the policy. Some were worried about unjust applications of the policy while others worried about the possibilities for fraud (Thorpe, 2007). Unlike the U.K, in the U.S., rationing coupons were printed out in the 1970s but with "no effective coordination among agencies", so coupons were easy to reproduce (Winkler, 1983, p. 52). The policy needs to involve coordination between several government units to provide staff, print and distribute coupons, and enforce the measure at local level (Thorpe, 2007).

- Work from the local level and volunteers is very important. However, some challenges may present themselves such as delayed data submission and transmission, inadequate trained volunteers and funds, a limited ability to supervise the local level, and treating people at the same standard (Phillips, 1945).

- Low-income groups are likely to show a more positive attitude toward rationing while high-income groups prefer purchasing gasoline at market prices (Hanafizadeh et al., 2010).

- An analysis of rationing measures is presented in Table 4.14. Rationing coupons can be transferrable or non-transferrable. Rationing can be fixed price or fixed quantity. Transferrable coupons with a fixed price create fewer negative impacts, and general rebates are better than rationing because the interaction between demand and supply at market-clearing prices eases the supply-side effects.

Table 4.14 Analysis of Rationing

Energy Contingency Plan	Rationing
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Prepare and update the database of registered vehicles or registered drivers, and update priority driving database - Set up preparedness plan and practice how to assign tasks to staff, how to issue coupons or cards that are hard to duplicate, and how to distribute them and enforce regulations - Cooperate with local staff and related units to prepare and enforce the measure at local level - Provide several travel options and public information to facilitate those who are unfamiliar

Energy Contingency Plan	Rationing
	with the new modes and prepare for other trip reduction measures such as working from home
Contribution to maintaining mobility (Limitation of mobility can affect equity and economy; better understanding and managing HO, NE, SE, DE reduce the limitation)	- Low contribution as commuters receive limited amount of fuel - Mitigate the problem by generating a package of oil saving measures (such as transit enhancement and carpooling) and trip reduction measures (such as telecommuting and compressed workweek)
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- Low public acceptance because of limited mobility, but public acceptance becomes higher if the crisis is severe and if people perceive that the rationing measure is effective and fair - Provide information involved with the severity and the necessity to enforce the measure, and information about the effectiveness and fairness of the measure - Focus on trust, provide tailored information about other travel modes, and other saving policies based on audiences - Ensure better communication channels among government units and consumers - Setting up a center, smartphone application, other communication channels to offer trip planning, information sharing, etc. to assist people to find and take advantage of fuel-efficient ways of traveling

Energy Contingency Plan	Rationing
Demand restraint potential and implementation time (Reduce fuel consumption and emission, but can impact economy and equity)	- Considerable fuel saving, but limited mobility, the measure should be used as a last resort (i.e., a serious shortage) - Takes time to implement because it requires considerable labor, costs, and cooperation with several units including local level
Funding sources (Economy, equity)	- Require laws to ensure funding sources for the high transaction cost at central and local levels
Equity considerations (Equity)	- Seems to be fairer than price allocation as rationing allocates fuels by highest value use; however, people might still feel that they are not treated fairly, and people might not be treated in the same standard - Transferrable coupons are fairer since some people might want to travel less or more than their rationing level, and this approach legally allows income transfer to those who save more fuel
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- A severe shortage with an expected long period should trigger the measure; particular percentages and scenarios should be mentioned to avoid the delay in decision-making processes - Need to monitor fuel prices and quantity supplied and demanded - Monitor the impacts and feedback at central and local levels - Barriers include a massive deficiency of data and information which lead to inaccurate analysis, the need for cooperation from several units,

Energy Contingency Plan	Rationing
	administrative difficulties, ease of coupon/card duplication, etc.
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- High effectiveness if a package of saving policies is implemented; people have more opportunities to travel and options for trip reduction - Substantial reduction in fuel consumption provides positive impacts on energy and environment. The economic and equity impacts depend on several factors such as the effectiveness of coupon distribution at the local level, the effectiveness of cooperation among governmental units, other available travel options, etc.

Note: The information originally comes from the articles listed in Table 4.13 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.7 Driving Restrictions

Driving restrictions have been enforced to cope with an oil crisis in the past. The policy becomes acceptable when it is perceived to be effective and fair. Recently, driving restrictions have been used to reduce emission and traffic congestion in some cities. This section employs 15 articles about different cities to explore different types of driving bans and the challenges found. The reviewed articles are shown in Table 4.15.

Table 4.15 Data Collection for Driving Restrictions

Authors, Year	Areas, Methodology
Armstrong-Wright, 1986	Developing countries, Qualitative analysis
Belk, Painter & Semenik, 1981	U.S. (Salt Lake City), Interviews
Davis, 2008	Mexico (Mexico City), Econometric model
De Grange & Troncoso, 2011	Chile (Santiago), Multiple linear regression models
Gallego, Montero & Salas, 2013	Mexico (Mexico City) and Chile (Santiago), Empirical data analysis and econometrics
Hao, Wang & Ouyang, 2011	China (Shanghai and Beijing), Qualitative analysis
Huang, Fu & Qi, 2017	China (Lanzhou), Regression discontinuity design
Humphrey, 1983a	U.S., Interview from the public and private sector
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Kumar, Gulia, Harrison & Khare, 2017	India (Delhi), Statistical analysis
Lee, 1983	Australia, New Zealand, U.K., Netherlands, Experiences and literature
Viard & Fu, 2015	China (Beijing), time-series analysis and spatial variation
Wang, Xu & Qin, 2014	China (Beijing), Survey, statistical analysis and nested logit model
Xie, Tou & Zhang, 2017	China (Beijing), Probabilistic modeling method
Yang, Liu, Qin & Liu, 2014	China (Beijing), Qualitative analysis

The carless day system, odd/even driving bans and similar measures are more likely to be utilized during an emergency while vehicle ownership restraints and other policies aiming to increase costs of driving and owning a vehicle are less feasible as they add more financial burdens during an oil crisis. These experiences remind policymakers and practitioners of the possible behavioral adaptations in response to the implemented measure.

- Driving restrictions to deal with traffic congestion and air pollution can be implemented in many ways. “Area licensing”, “parking restraints”, “user taxes” charged on fuels, or other added costs based on distance traveled, and “vehicle ownership restraints” (Armstrong-Wright, 1986). However, during a normal circumstance, cities in several developing countries cannot employ these measures because of “political factors” (Armstrong-Wright, 1986, p. 123).

- Vehicle ownership restraints can be employed in several ways. In China, the government tries to slow down the number of vehicles using different methods across the country. Beijing first implemented a registration lottery in 2011 while Shanghai uses auctions and Guangzhou uses a combination of both methods (Yang et al., 2014).

- Several experiences of cities implementing driving restrictions show side effects and ways to circumvent the regulations. Slowing down registered vehicles by auction involves fairness issues (Hao et al., 2011) while capping vehicle quantity by lottery involves inefficient allocation and illegal ways to own a car (Yang et al., 2014). Both ways just slow down the growth of the number of vehicles on the roads (Xie et al., 2017; Yang et al., 2014) and generate net economic losses (Xie et al., 2017). Furthermore, those who own cars tend to buy fuel inefficient cars and drive intensively (Xie et al., 2017; Yang et al., 2014).

- Driving restrictions are often enforced with rationing during an oil supply disruption. In New Zealand in mid-1979, the public did not resist the driving restriction policy because they felt that they had no other options (Lee, 1983).

- Like rationing policy, driving restrictions are an unfavorable measure. Even though they can more effectively reduce gasoline consumption than education information and other policies (Lee, 1983; Humphrey, 1983a; Belk et al., 1981), it requires considerable explanation for public acceptance (Lee, 1983) and high costs to prepare and administer (Humphrey, 1983a).

- Odd and even day driving bans or similar methods are also enforced to reduce driving in order to reduce emission and traffic congestion in some cities as well. The experiences from different cities are presented below.

  - A driving restriction measure introduced in Mexico City in 1989 was meant to reduce driving and mitigate air pollution. The measure banned driving based on the "last digit of the vehicle's license plate" one weekday (Davis, 2008, p. 39). Some researchers indicate that the measure was effective in the short run as people purchased more cars and kept their old cars (Gallego et al., 2013; IEA, 2015b). Transit use did not augment. Also, a slight increase in taxi ridership was found as taxis were excluded from the ban (Davis, 2008). The number of cars and a change in the age of vehicles toward older ones increased and led to higher pollutants (Davis, 2008).

  - Lanzhou is an industrial and polluted city in the northwest of China. The government has implemented the same measure as the earlier example and when pollution reaches a certain point, an odd/even driving ban is additionally enforced (Huang et al., 2017). The measure is effective only in the short run; however, drivers' adaptations and the purchases of additional cars have led to a rebound effect (Huang et al., 2017).

- In Santiago, the government implemented two driving restriction measures in 2008. The first one applies to vehicles without catalytic converters. The second one applies to vehicles with catalytic converters (De Grange & Troncoso, 2011). The first measure did not make a remarkable change in driving. The additional driving restriction measure reduces driving more. The urban rail is perceived to be better than the bus as car users are more familiar with the metro (De Grange & Troncoso, 2011).

- In the late 2000s and the early 2010s, Beijing tried to limit vehicle use through a series of odd/even days driving (Hao et al., 2011). The policies have resulted in decreased work hours because of increased travel costs among business owners and entrepreneurs (Viard & Fu, 2015). Living far from the inner city with poor transit accessibility are not the only reasons. People tend to violate the rules because of fewer surveillance cameras and police patrols. Several methods are used to circumvent the restrictions (Wang et al., 2014).

- Delhi used an odd/even driving ban in winter 2016 and another 2 weeks in summer 2016 to diminish air pollution. About 20 vehicle categories were exempted from the restriction (Kumar et al., 2017). The winter months are found to have a higher particle matter concentration while the monsoon (June-August) has the lowest particle matter concentration because of different meteorological factors together with non-transportation activities (Kumar et al., 2017).

- Driver always “find ways to circumvent” (Davis, 2008, p. 79) measures that do not suit their lifestyles (IEA, 2005b; Wang et al., 2014; Gallego et al., 2013). To avoid this unsuccessful experience, an analysis to prevent the substitution patterns should be considered in advance (Davis, 2008). The driving restrictions is found to be effective only in the short term because many people purchase a second car to substitute for the banned vehicle on a given day (IEA, 2005b; De Grange & Troncoso, 2011; Huang et al., 2017; Wang, et al., 2014). The measure becomes less effective if it affects only a small number of cars and has an unequal impact on the poor that drive less (De Grange & Troncoso, 2011). Violations of driving restriction take place in areas with fewer surveillance cameras and police patrols (Wang, et al., 2014; De Grange & Troncoso, 2011). The methods to circumvent the driving restrictions include covering plates, borrowing plates from others, going out before or after the restricted times, simply ignoring the driving bans, and later purchasing another car for substitution (Wang et al., 2014; De Grange & Troncoso, 2011).

- The measure becomes more effective if other travel options rather than private cars are available (IEA, 2005b). For the longer-term effect, the driving bans need a more circumspect policy design, a package of instruments (Gallego et al., 2013), an incentive, an integrated transit system, several modes of transportation offered, and an appropriate public information (Huang et al., 2017).

- In the case of a crisis, the measure becomes more effective if civil society perceives the necessity to conserve energy and it then becomes more politically acceptable (IEA, 2005b).

- An analysis of driving restrictions is presented in Table 4.16. There are several strategies to limit driving (such as road pricing, vehicle registration by auction, etc.), but only carless day systems or similar methods such as odd/even day driving bans are included here since the methods can be feasibly enforced during a crisis.

Table 4.16 Analysis of Driving Restrictions

Energy Contingency Plan	Driving Restrictions
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Prepare and install surveillance cameras and other facilities to enforce the measure more effectively - Cooperate and perform preparedness plan practice with several government agencies, local units, and related private sector - Identify the details such as designated areas, trained personnel, possible means of violation and how to prevent them, priorities and exemptions - Provide several travel options and public information to facilitate those who are unfamiliar with the new modes and prepare for other trip reduction measures such as working from home
Contribution to maintaining mobility (Limitation of mobility can affect equity and economy;	- Low contribution, but offering several travel options and implementing trip reduction measures such as working from home and telecommuting can alleviate some difficulties

Energy Contingency Plan	Driving Restrictions
better understanding and managing HO, NE, SE, DE reduce the limitation)	
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- Low public acceptance because of limited mobility, but public acceptance becomes higher if the crisis is severe and if people perceive that driving ban measures are effective and fair - Provide information involving the severity and the necessity of enforcing the measure, the effectiveness and fairness of the measure, other travel options and trip reduction measures, etc. - Focus on trust, provide tailored information about other travel modes, and other saving policies based on audiences - Set up a center, smartphone application, better communication channels to offer trip planning, information sharing, etc. to assist people to find and take advantage of fuel-efficient ways of traveling
Demand restraint potential and implementation time (Reduce fuel consumption and emission, but can impact economy and equity)	- Considerable fuel savings, but with limited mobility and high social costs, the measure should be used as a last resort (i.e., a serious shortage) - Take time to implement if equipment and facilities used to enforce, police, and trained personnel are not ready
Funding sources (Economy)	- New sources of funding for equipment and facilities not required if they are already available for other objectives not specific to driving bans

Energy Contingency Plan	Driving Restrictions
	- Require more funding for police and other personnel to patrol for this special program
Equity considerations (Equity)	- Seem to be fair, but the rich tend to have more than one car for a substitution, and in a long term they tend to buy more vehicles while the poor keep old cars which pollute more and increase the risk of accidents - The fairness increases if people have more travel options with good quality and affordability
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- A particular degree of physical shortage with expectation of long period should trigger the measure - Monitor and prevent the methods of violation and the ways to circumvent the measure such as covering plates, borrowing plates from others, going out before or after the restricted times, simply ignoring the driving ban measure in the areas with fewer surveillance cameras and police patrols, later purchasing another car, and more taxi riders - Monitor for difficulties and special needs that might need exceptions and revise the restriction - Require high degree of monitoring and patrolling while people always find a way to circumvent the measure to suit their lifestyle
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with	- High effectiveness only in the short run - Providing a package of saving policies can increase the effectiveness

Energy Contingency Plan	Driving Restrictions
consideration of HO, NE, SE, DE)	- The measure can reduce fuel consumption but might not ensure equity; possible negative impacts include economy, accidents and air pollution from keeping old cars, illegal practices in society, surveillance burdens on police, etc.

Note: The information originally comes from the articles listed in Table 4.15 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.8 Non-Motorized Modes

This section employs 16 articles to explore how to enhance non-motorized modes (i.e., walking and biking). The reviewed articles are presented in Table 4.17. This section finds that to minimize difficulties during a crisis and to sustain the use of non-motorized methods of transport, several measures take significant time to implement, as they require the improvement of infrastructure, an urban setting, and other push and pull measures in favor of walking and biking. Seasonality, health concerns, demographic factors and socioeconomic factors can influence the shift to non-motorized modes.

Table 4.17 Data Collection for Non-Motorized Modes

Authors, Year	Areas, Methodology
Courtemanche, 2011	U.S., Data from telephone surveys done by state health departments and the Center for Disease Control, and regression analysis

Authors, Year	Areas, Methodology
Dare, 1983	U.S. (rural areas), Data and survey on local government
Davies & Weston, 2015	U.K. (the Welsh Marches), interviews with walking group leaders
Grischkat, Hunecke, Bohler & Haustein, 2014	Germany, Mobility diaries and in-depth interview
Hanson, Noland & Brown, 2013	U.S. (New Jersey), Google Street View imagery, a case-control methodology, and binomial logit model
Hong, 2016	U.K. (Scotland), Data from Scottish Household Survey and multinomial logit model
Ishaque & Noland, 2008	U.K. (London), Micro-simulation model and air dispersion model
Longo, Hutchinson, Hunter, Tully & Kee, 2015	U.K. (North Ireland) Surveyed 1209 people in 2010-2011 and used a Tobit model
Martens, 2007	The Netherlands, Qualitative analysis
Mullen, Tight, Whiteing & Jopson, 2014	U.K., Theoretical conception of political and social equality
Noland & Kunreuther, 1995	U.S. (Philadelphia, PA), Mail survey and multinomial logit models
Noland, Polak, Bell & Thorpe, 2003	U.K. (London, South East, and North East), Telephone survey after the crisis ended for 2 months
Rothman, To, Buliung, Macarthur & Howard, 2014	Canada (Toronto), Observational study and statistical analysis
Santos, Behrendt & Teytelboym, 2010	Unspecified area, Literature on policy instruments

Authors, Year	Areas, Methodology
Song, Preston & Ogilvie, 2017	U.K., Data from the Impact of Constructing Non-Motorized Networks and Evaluating Changes in Travel study and mailed survey
Van Malderen, Jourquin, Thomas, Vanoutrive, Verhetsel & Witlox, 2012	Belgium, Data from the home-to-work travel survey and binary choice model

- During the crisis in 2000, a British survey finds increases in bicycle riding by 48% and walking by 41% , and the shortage did not have a large effect on those who traveled by non-motorized modes. They also had less concern over a future shortage (Noland et al., 2003).

- In the 1970s crises, biking was an option in the U.S., but there were concerns about safety such as steep hills in some areas and no program of bicycle route development (Dare, 1983). “Death and injury” caused by poor infrastructure, “fear” of walking and biking on the road, and pollution exposure indicate that pedestrians and cyclists are not treated equally compared with drivers (Mullen et al., 2014, p. 238). Biking can be dangerous. The significant risk factor is the unavailability of shoulders on the roads while insignificant risk factors are potholes and other poor road conditions, bad or inattentive drivers, heavy traffic, and weather factors (Noland & Kunreuther, 1995). Perceptions of danger and the safety of biking and using public transit need to be improved by managing and building appropriate infrastructure (Van Malderen et al., 2012). Creating greater equality in transportation should involve minimizing deaths associated with transportation by “avoiding inequalities in life-threatening risks”, and increasing “accessibility to other means of travel” (Mullen et al., 2014, p. 242).

- Appropriate non-motorized infrastructure is important but are not sufficient factors to make people change modes of transportation (Song et al., 2017); as a result, the improvement of “an integrated transport system” and other related issues are needed to make the policies successful (Noland et al., 2003, p. 478; Santos et al., 2010). Enhancing non-motorized modes requires push and pull measures (Van Malderen et al., 2012).

- Pull measures for walking and biking consist of cutting crime rate for safer sidewalks, well-maintained sidewalks, safer crosswalks with lower waiting times, bathrooms at offices (Santos et al., 2010), dedicated biking lanes (Santos et al., 2010; Noland & Kunreuther, 1995), and special or exempted bus and train fares for cyclists (Grischkat et al., 2014). Other incentives are attractive and walkable areas with stores and amenities (Longo et al., 2015) that cater to the needs of those passing by, “availability of bikes for work trips, provision of bike racks” (Van Malderen et al., 2012, p. 14) and other bicycle facilities (Noland & Kunreuther, 1995; Van Malderen et al., 2012), ensuring "a safe and efficient network” of bike lanes (Noland & Kunreuther, 1995, p. 78), provision of “information about bike routes” (Van Malderen et al., 2012, p. 14), utilization of advanced technology and media, and changes in group norms regarding fuel saving and environment (Davies & Weston, 2015).

- Push measures such as “reducing the number of parking places” (Van Malderen et al., 2012, p. 14), making driving more difficult by prohibiting automobile traffic in various areas, and limiting speed (Noland & Kunreuther, 1995) can encourage more biking and taking public transportation. Changing gasoline prices in a way that leads to healthier lifestyles and exercise decisions (Courtemanche, 2011) can encourage non-motorized modes.

- Improving road infrastructure to elevate pedestrian safety is necessary. Policymakers have to pay more attention to "the interaction between pedestrians and motor vehicles" and build "complete streets" that provide "safe access to the roads for all users" rather than only for drivers (Hanson et al., 2013, p. 52).

- The policy to enhance non-motorized modes might not always offer positive impacts. Some negative impacts that offset the benefits should be taken into account. A study from London shows that the difference in exposure to pollution is insignificant between short and long traffic signal cycles. At crosswalks with long signal cycles, pedestrians expose to lower pollution concentration at a longer period and wait times. With short signal cycles, pedestrian expose to higher pollution concentration at a shorter period and wait times (Ishaque & Noland, 2008). Pedestrians with slow walking speeds such as "the elderly, sick, disabled", and children who have a "lower breathing height" are likely to be more affected by emissions (Ishaque & Noland, 2008, p. 44).

- In several places, people walked and biked for leisure, not initially for commuting trips. Different places show different patterns and purposes of walking and biking (Song et al., 2017).

- Promoting non-motorized modes should not only focus on commuting to work, but also focus on non-work trips such as leisure trips (Davies & Weston, 2015), going to school, and so on. To make walking more feasible for students, adding "school crossing guards” and some “specific roadway design features” are helpful (Rothman et al., 2014, p. 14).

- Policymakers should incorporate the effects of seasonality and urban settings into their plans and analysis. In Scotland, significant seasonality effects indicate that short daylight hours, rain, and low temperatures in the winter lead to less walking while more walking occurs in the summer (Hong, 2016). The seasonality effects are “stronger in rural areas than urban areas” (Hong, 2016, p. 147).

- Walking is appropriate for everyone, not excluding overweight and older people, and help diminish the risks of heart and blood vessel diseases as well as cancer (Longo et al., 2015). Policymaking should aim to increase walking behavior in both active and inactive people, provide more attractive incentives for inactive groups, and actively send the message to all that walking makes them healthier (Longo et al., 2015).

- “Employment status” is a key factor determining travel behavior (Song et al., 2017, p. 328). Policy interventions should consider “important life changes” (Song et al., 2017, p. 328; Santos et al., 2010) as the interventions can alter the regular travel behavior for new circumstances (Song et al., 2017).

- A survey in Philadelphia indicates that many people live too far to use non-motorized modes to commute to their workplaces, and public transit is not poorly available. As a result, these people have to rely on cars (Noland & Kunreuther, 1995).

- The Dutch experience shows that measures to connect bike and train increase consumer satisfaction, increase bike-and-ride participants, and increase a modal shift from cars to trains (Martens, 2007). Several programs and master plans promote bike-and-train riding through increasing bike parking capacity to a level that ensures its availability, having secure guarded parking and lockers at all train stations, upgrading existing facilities, etc. (Martens, 2007). The challenging issue is the "lack of attention" paid to biking and the lack of an "involved authority". Accessibility to public transportation stops is not assigned to particular units (Martens, 2007, p. 336). Although safe bicycle routes and sufficient and attractive bicycle parking facilities are the most important successful key factors, "conformity and peer effects" are another reason for the success of bike-and-ride programs in the Netherlands (Martens, 2007, p. 336).

- An analysis of non-motorized modes is presented in Table 4.18. The measure maintains mobility and saves fuel at the same time. Implementing non-motorized modes during a crisis is not effective if the major concerns such as safety, pollution exposure, weather extremity, and road infrastructure are not improved. Also, increasing the costs of driving is important. The strategies include providing better street furniture for pedestrians and bikers, adding crossing guards, and implementing bike-and-ride programs.

Table 4.18 Analysis of Non-Motorized Modes

Energy Contingency Plan	Non-Motorized Modes
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Provide walking and cycling infrastructures and favorable environments such as crime reduction for safer streets, well-maintained sidewalks, and dedicated biking lanes,

Energy Contingency Plan	Non-Motorized Modes
	- Ensure integrated policies (e.g., bike and ride, biking for health purposes and the environment) - With various involvements and objectives, it is necessary for several government units and private sector to cooperate
Contribution to maintaining mobility (Provide an option to travel under E4 perspectives; better understanding and managing HO, NE, SE, DE increase its contribution)	- High contribution to maintaining mobility for those who live in walkable land uses and available non-motorized mode infrastructure - Those who live far from their workplace might not be able to take advantage
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- High public acceptance if people can walk and bike safely without fear - Encourage conformity and peer effect - Connect warm glow, praise, healthy workout, and zero pollution with oil saving benefit - Employ social and behavioral theories mentioned in section 4.1.2.10 for tailored information provision; for example, encouraging the rich to switch to non-motorized modes by focusing on an opportunity to exercise while they are commuting; informing guardians and students about the increased number of school crossing guards and some specific roadway design features to ensure the students' safety
Demand restraint potential and implementation time	- Significant fuel saving as the non-motorized modes allow people to travel without fuel

Energy Contingency Plan	Non-Motorized Modes
(Independence on fuels, maintain economic activities, consider equity, mitigate environmental degradation)	- Take time to build, adjust, change the infrastructure and favorable environment, as a result, higher effectiveness requires pre-implementation activities
Funding sources (Economy, equity)	- Funding from oil taxes and other taxes - Budgets for health, tourism, crime, and environment should be used as the non-motorized modes have multiple benefits
Equity considerations (Equity)	- High level of equity as most people can participate except for those who live far from their workplace or live in high-crime areas - Pedestrians and cyclists are not treated equally compared with drivers because of poor infrastructure, fear of walking and biking on the road, and pollution exposure
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- Increasing fuel prices can trigger the measure at early stage - Monitor for the concerns, problem interactions between the pedestrians/bikers and motor vehicles, for example, pedestrians with slow walking speed, people with wheelchairs, and children who might be exposed to severe air pollution - Monitor the interaction between other saving policies and the non-motorized modes, for example, carpooling might draw people from walking/biking

Energy Contingency Plan	Non-Motorized Modes
	- Lack of attention to biking and walking and no involved authority - Equality in transportation between walkers/bikers and drivers
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- High effectiveness if there are supportive infrastructures, connectivity with other modes, and social norms and peer effects - Increase effectiveness by implementing the pull measures and the push measures simultaneously; for example, subsidizing fuel prices lessens the effectiveness of non-motorized modes - Seasonality such as rainy seasons or short daylight hours might discourage walking and biking

Note: The information originally comes from the articles listed in Table 4.17 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.9 Eco-Driving

The eco-driving policy was implemented several decades ago. Speed limit reduction policies as a way to reduce oil consumption are enforced to cope with a supply disruption. Recently, concerns about climate change have drawn attention back to an eco-driving policy. This section focuses on policy issues, rather than technical and mechanical issues. Eco-driving usually involves public information and campaigns; however, other saving policies require good public information as well. Thus, public information is specifically presented in another section, section 4.1.2.10. This section reviews 10 articles as shown in Table 4.19. The more recent articles suggest sustaining eco-driving behavior by making it the norm for driving behavior, utilizing advanced technology, and targeting myths.

Table 4.19 Data Collection for Eco-Driving

Authors, Year	Areas, Methodology
Alam & McNabola, 2014	Unspecified area, Literature on eco-driving policy
Barkenbus, 2010	U.S., Qualitative analysis based on behavioral research
Barla, Gilbert-Gonthier, Castro & Miranda-Moreno, 2017	Canada (Quebec), Random coefficient model
Beusen, Broekx, Denys, Beckx, Degraeuwe, Gijsbers, Scheepers, Govaerts, Torfs & Panis, 2009	Belgium, Onboard logging devices to collect information
Carrico, Padgett, Vandenbergh, Gilligan & Wallston, 2009	U.S., Online survey
Hartgen & Neveu, 1980	U.S. (NY), Survey on 1,520 New York residents
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Lee-Gosselin, 2010	U.S., Canada, Literatures and shortage simulation
Mensing, Bideaux, Trigui, Ribet & Jeanneret, 2014	Unspecified area, Dynamic programming optimization method
Wolff, 2014	U.S. (Washington State), Weekly data estimation models

- Speed limit reduction on motorways is one of the components of an eco-driving policy. Lower speed limits are claimed to reduce gasoline consumption effectively. During the 1970s, the U.S. imposed a 55 mph (90 km/h) speed limit (Lee-Gosselin, 2010), and found that the measure was effective at the beginning because of "altruistic behavior and a determined enforcement regime" (IEA, 2005b, p. 106).

- A speed limit reduction policy requires clarification which the civil society can connect between speed reduction and energy savings. It also requires infrastructure such as signs and equipment such as speed cameras. Personnel to enforce the measure are also vital (IEA, 2005b).

- In the 2000s, a dollar increase in gasoline prices was associated with a 0.27 mph decline in speeds in Washington State in the U.S. However, in some places, it was found that vehicle speed increases as prices of oil increase because of fewer cars on the roads (Wolff, 2014).

- Speed limit can contribute a large saving that requires a low cost of implementation (IEA, 2005b; Barkenbus, 2010). Safety is considered another potential benefit of a speed limit reduction policy (IEA, 2005b).

- Promotion of eco-driving cuts back fuel consumption by 10-20% for those who actually take action (IEA, 2005b; Barkenbus, 2010). Although some studies might find a higher saving effect based on experimental conditions, a 5% fuel saving is expected on the real road (Alam & McNabola, 2014).

- Policymakers should not overlook negative side effects of the eco-driving policy. Driving too slowly can generate negative consequences (Hartgen & Neveu, 1980).

Some evidence points out “unusual driving behavior”, “increased overtaking, and annoyance” (Alam & McNabola, 2014, p. 47) resulted from eco-driving. A rise in average commute time is another potential cost of eco-driving (IEA, 2005b), and it increases emissions because of longer time driving on roads, especially in congested urban areas with many intersections (Alam & McNabola, 2014). At the economic fuel optimal point, eco-driving can decrease fuel use, but it raises CO and HC emissions. In other words, eco-driving might not always reduce emissions (Mensing et al., 2014). A better combination of “velocity and acceleration rates” that incorporates a reduction in fuel consumption and emissions should be optimized (Mensing et al., 2014, p. 120) for eco-driving.

- Eco-routing, which expects to “reduce total network trip” duration (Alam & McNabola, 2014, p. 44), might not necessarily be the shortest route and travel time. The advantage of a better traffic flow may be offset by driving faster (Alam & McNabola, 2014). Navigation devices for fuel optimization can distract drivers and lead to accidents (Alam & McNabola, 2014).

- Information on eco-driving can be disseminated through eco-driving training, aggressive campaigns regarding public information with necessary details and education (IEA, 2005b), and utilizing technologies presenting feedback on how fuels are consumed (IEA, 2005b; Carrico et al., 2009).

- Eco-driving training is expected to save fuel by 25%, but eco-driving behaviors might not be sustained for long, and the actual saving is claimed to reduce fuel consumption by 5-6% (Barkenbus, 2010; Beusen et al., 2009, Barla et al., 2017). Fuel saving is found to reduce after 7-10 months, and the cost saving is estimated to be a moderate-impact method (Barla et al., 2017). Thus, in order to sustain eco-driving behavior, other strategies are required.

- Positive feedback and reinforcement to encourage energy conservation actions are needed as fuel saving is claimed to double because of its consistent reminder (Barkenbus, 2010). Hybrid-electric vehicles these days offer the option to present the feedback or even operate in an eco-driving mode. Monitoring devices can be installed at the cost of $150 (Barkenbus, 2010).

- In order to have more participation and involvement, eco-driving training and feedback devices should be subsidized by either public or private sectors and promoted via specific events (Barkenbus, 2010). In addition, those who take eco-driving train course and show improved performance on the road should be offered a discount for car insurance (Barkenbus, 2010).

- Eco-driving should be the norm of driving behavior, not the exception (Barkenbus, 2010; Barla et al., 2017) for a longer-term impact. "A sophisticated multidimensional campaign involving education, regulation, fiscal incentives, and social norm reinforcement" (Barkenbus, 2010, p. 765). is required to attract those who generally do not pay attention, and social marketing can be a strategic tool (Barkenbus, 2010).

- Outdated information and myths should be targeted. Many Americans hold outdated beliefs; for instance, 80% of the drivers in the U.S. report that to "save fuel and money, reduce emissions, and prevent vehicle wear and tear" (Carrico et al., 2009, p. 2886), they should idle a vehicle for 30 seconds or longer rather than shut off and restart the engine. In fact, warming up the engine is unnecessary for most modern engines, and idling for 10 seconds or more causes more wear and tear than restarting (Carrico et al., 2009).

- An analysis of eco-driving is presented in Table 4.20. The policy can save fuel at large levels and requires low implementation cost. Eco-driving or behavioral changes can be encouraged with public information, regulations, pecuniary incentives, and social norm strengthening. The policy can draw more attention during a crisis, but it is more challenging to sustain the behavior in the long term.

Table 4.20 Analysis of Eco-Driving

Energy Contingency Plan	Eco-Driving
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Identify the eco-driving behavior and some specific information - Identify myths and popular beliefs that need to be corrected - Cooperate with private sector, other government units, experts, and media to prepare to disseminate information effectively via several channels and set up a short eco-driving training program to be ready to use - Prepare for laws and agreements to be used such as speed limits on the highway, agreement with the auto service centers to check tire pressure for free, etc.
Contribution to maintaining mobility (Provide better efficient way of driving under E4	- Maintain mobility at normal levels with more efficient fuel consumption

Energy Contingency Plan	Eco-Driving
perspectives; better understanding and managing HO, NE, SE, DE increase its contribution)	- Some people might argue against increased travel time and practical issues such as driving in urban areas where there is congestion and many intersections
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- High acceptance because people can maintain mobility and save travel costs; however, deviation between intention and action is likely to occur - Focus on how the information provision changes driving behavior - Have experts and the persons perceived as most credible and trustworthy disseminate the information, prepare information content that is simple but vivid (please see the section 4.1.2.10) at pre-implementation stage - Focus on outdated information and myths and the costs incurred if behaviors related to those beliefs do not change, and provide tailored information for those who drive in different areas - Sustain eco-driving behavior by making eco-driving the norm - Impose monetary costs if people do not change
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, consider	- Large oil saving with quick implementation, but it needs to reduce deviation between intention and action and requires well-planed campaigns - Fuel price subsidies discourage eco-driving - Other saving measures such as working from home, carpooling, etc. are needed to save additional gasoline

Energy Contingency Plan	Eco-Driving
equity, mitigate environmental degradation)	
Funding sources (Economy, equity)	- Oil taxes and other taxes - Private funding with agreements or a method to promote businesses and sales, for example, automobile industry sponsors for an eco-driving events
Equity considerations (Equity)	- Everyone can participate - The poor tend to drive old cars without feedback devices and installing the devices is not an option, so subsidizing feedback devices and providing eco-training courses at no cost are important
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- With low cost to implement, the policy can be triggered at very early stage of rising fuel prices - Monitor side effects that take place such as increasing travel time, pollution, accidents, etc. - Monitor deviation between intention and action, for example, the speed that might increase on empty streets, taking nonessential items out of cars - Behavioral change is the barrier, and sustaining behavioral change is even harder
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- High effectiveness can be reached if oil prices stay high and the government uses effective information provision, regulation, incentives, and social norm strengthening to change behaviors - In general, eco-driving reduces fuel consumption, maintains economic activities, affects people fairly, and mitigates emissions; however, there are some

Energy Contingency Plan	Eco-Driving
	possible negative impacts such as accidents from distractions and emissions from increased travel time

Note: The information originally comes from the articles listed in Table 4.19 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.10 Public Information

This section utilizes 17 articles discussing public information during a crisis and normal circumstances, and the reviewed articles are presented in Table 4.21. Public information is a crucial part of coping with an emergency, and it requires preparation before a crisis starts in order to have effective communication and minimize barriers. Sources dealing with general public information used for energy conservation in the household are important in this section as the information is available and can be applied to transportation. The strategy relies on social-psychological aspects of behavioral and social studies regarding actual saving behaviors and sustaining them for a longer term.

Table 4.21 Data Collection for Public Information

Authors, Year	Areas, Methodology
Anderson, 1983	U.S., Experiences
Barker, 1983	U.S. (TX, MN, WI, CA, VA, MD, WA, TN, OR, CO, NY), Experiences
Belaid & Garcia, 2016	France, Data from a governmental survey, Item Response Theory (IRT) and multivariate regression

Authors, Year	Areas, Methodology
Carrico, Padgett, Vandenbergh, Gilligan & Wallston, 2009	U.S., Online survey
Costanzo, Archer, Aronson & Pettigrew, 1986	Unspecified area, Literature on behavioral and social researches
Davis, 1983	U.S., Survey on transit authorities
Dennis, Soderstrom, Koncinski & Cavanaugh, 1990	Unspecified area, Literatures reviewed
Frederiks, Stenner & Hobman, 2015	Unspecified area, Qualitative analysis with behavioral economics and psychology
Hartgen, Brunso & Neveu, 1983	Several cities in the U.S., Studies and Survey in NY
Hartgen & Neveu, 1980	U.S. (NY) Survey on 1,520 New York residents
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Sheau-Ting, Mohammed & Weng-Wai, 2013	Malaysia, Questionnaire developed from choice-based conjoint analysis
Lee, 1983	Australia, New Zealand, U.K., Netherlands, Experiences and literature
Lutzenhiser, 1992	Unspecified area, Qualitative analysis of different approaches of energy consumption
Lyons & Chatterjee, 2002	U.K., Survey conducted right after the crisis ended
Schueftan, 1983	U.S., Studies from DOT based on the interview
Steg, 2008	Unspecified area, Psychological literature

- The effective contingency plan should have related and ready-to-use laws and regulations, responsibility and role assignments, accuracy and credibility of public information (Lee, 1983), public awareness, and participation from civil society to make sure policy acceptance and adaptation (IEA, 2005b). An energy contingency plan that attempts to conserve energy should maintain mobility and ensure public confidence (Davis, 1983). The plan and situation should be monitored and assessed as well (IEA, 2005b).

- "Public communications and a public information program" to keep people from panicking and misinformation are vital during a crisis (Anderson, 1983, p. 21).

- Challenging issues are found during an emergency. The gasoline stations sometimes were unwilling to work with government agencies who needed to collect the information (Barker, 1983). Disseminating transit information is vital, but the effectiveness is questioned. . During a crisis, people adjust their behavior, but they need information about various travel modes to make an adjustment that fits their lifestyle best (Barker, 1983). However, insufficient communication, an overloaded information system, (Barker, 1983) and unfamiliarity with transit system (Schueftan, 1983) were the problem during the 1979 crisis

- The plan should prepare to "inform first-time transit riders about routes and schedules", and "all riders should be informed about any changes" during a crisis. (Davis, 1983, p. 92). Governments should "provide information to the appropriate groups at the local level" (Hartgen et al., 1983, p. 50). For example, Carpooling is more popular for larger households with cars (Hartgen & Neveu, 1980); as a result, targeting this group with information about eco-driving and smart programs on route options is more useful.

- During a crisis, people are likely to welcome the fuel-saving measures and public information, as they want to find travel options during times of high fuel prices and/or shortages (IEA, 2005b). Social norms and people's beliefs are temporarily changed during a crisis. For example, "taking a bus does not result in a loss of social status during a crisis because other people do so" (Lyons & Chatterjee, 2002, p. 151).

- "Social and behavioral theories" are needed to supplement "the rational-economic model" to effectively disseminate energy information, (Dennis et al., 1990, p. 1109). Attitude about energy conservation does not significantly lead to actual savings (Costanzo et al., 1986). This is "an intention-action gap" (Frederiks et al., 2015, p. 1386) that policymakers often fail to consider.

- People are likely to accomplish a satisfactory, instead of the best option when information is overloaded or too complicated (Costanzo et al., 1986; Frederiks et al., 2015). The energy saving messages with recent, concrete, simple, repetitive, personally relevant, vivid, emotionally charged (Frederiks et al., 2015; Costanzo et al., 1986), and familiar (Dennis et al., 1990) information are the most absorbed by energy consumers.

- The "threat of loss" generates a higher influence than the promise of equivalent gain (Costanzo et al., 1986, p. 524; Frederiks et al., 2015). Furthermore, considering "characteristics of a target audience" and "tailoring messages" can increase communication effectiveness (Frederiks et al., 2015, p. 1389; Abrahamse et al., 2007).

- The energy saving measure should focus on the certain ongoing losses and costs for people if they do not change, and focus on the benefits if they do change (Frederiks et al., 2015). “Social comparisons” and “social norms” are also suggested strategies (Dennis et al., 1990, p. 1112, Frederiks et al., 2015, p. 1390).

- Goal setting is another strategy to reduce energy consumption to levels that could be considered challenging (Abrahamse et al., 2007). Feedback about personal energy saving is another effective strategy where consumers know information about how they compare with others (Abrahamse et al., 2007).

- Praise, having the worm glow, and social approval are desired (Dennis et al., 1990; Frederiks et al., 2015), especially when energy conservation or an innovation is “not an economically rational choice” (Dennis et al., 1990, p. 1113) or for a longer-term effect (Frederiks et al., 2015). People want to see lists of choices, advantages and disadvantages, but they want to make their own decision.

- The message should come from a perceived “credible and trustworthy” source (Frederiks et al., 2015; Costanzo et al., 1986, p. 527). Moreover, “creating partnerships between low and high credibility sources, utilizing grass-roots organizations and preexisting neighborhood groups, creating new organizations” (Costanzo et al., 1986, p. 524) are useful. Information communicated via “interpersonal channels” such as through respected friends and neighbors is more striking and credible than that circulated through media sources (Costanzo et al., 1986, p. 527).

- Cultures or lifestyles may make social groups different from one another (Lutzenhiser, 1992). People of different ages and households with young children have different energy conserving behaviors and respond to particular information differently (Belaid & Garcia, 2016, p. 212).

- Where and when to perform the desired behavior or saving behavior involves "accessibility to information" regarding energy conservation, and the "surrounding environment" to facilitate behavior change and "increase awareness and knowledge" (Sheau-Ting et al., 2013, p. 199).

- Environmental improvement (Abrahamse et al., 2007; Steg, 2008), perceived fairness and expected effectiveness of the program, increased freedom of alternatives (rather than curtailment), and preparation for side effects make energy saving more acceptable (Steg, 2008).

- Misunderstandings of fuel use exist (Costanzo et al., 1986). Outdated information and myths regarding energy saving behaviors should be targeted and corrected (Carrico et al., 2009).

- High disposable income people and people with ownership of high technologies are relatively able to buy or invest in expensive innovative technologies (Costanzo et al., 1986) such as assistance programs regarding installation and maintenance without cost or with very low cost for the poor (Costanzo et al., 1986). For transportation, low-income households should receive some form of subsidy such as free car tune-up, free eco-driving training, accessibility to public transit and carpooling, and so on. Public information should target those who use rental cars and company cars as well.

- Public information is a vital tool used along with the 9 saving policies. Using social and behavioral theories, goal setting, and tailored information is suggested. Table 4.22 presents an analysis of public information.

Table 4.22 Analysis of Public Information

Energy Contingency Plan	Public Information
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Cooperate with private sector and media to set up public information plan involving the information content, strategies, delivery channels, information sources, participation from the public, etc. - Prepare to use technology along with social and behavioral theories to disseminate the information - Require regulations to acquire data and information from private sector to cope with data deficiency during a crisis - Assign a team to update data and information as people change their behavior during a crisis - Work with local levels to create trust, prevent misinformation, and share concerns and assistance
Contribution to maintaining mobility (Provide information to meet E4 perspectives or reduce the negative impacts; better understanding HO, NE,	- Public information does not directly maintain mobility but it enhances the effectiveness of each saving policy, for example, easy and interactive information about public transit can increase transit ridership with higher satisfaction

Energy Contingency Plan	Public Information
SE, DE increases its contribution)	
Public acceptability/ information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- For high acceptance during a crisis, people want to know the options to reduce costs while maintaining their lifestyle and want to know what is changed - Use social and behavioral theories, goal setting, and tailored information as strategies - Aim to maintain mobility and accessibility, and relieve the difficulties (the rising prices and shortages)
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, consider equity, mitigate environmental degradation)	- Public information does not directly generate oil saving, but it is a tool to enhance the effectiveness of each saving policy and reduce confusion, panic, misinformation, anger, etc. - Provide information at an early stage to prevent misinformation and create trust
Funding sources (Economy, Equity)	- Oil taxes and other taxes - Require laws to make the funding available rapidly - Private sources or the combination of public and private sources of funding
Equity considerations (Equity)	- Ensure that low-income groups, senior citizens, disabled citizens, villagers, and other vulnerable groups have access to the information; as a result, having various disseminating channels is vital.
Monitoring, triggering mechanism,	- Rising fuel prices trigger the policy at early stage

Energy Contingency Plan	Public Information
institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- Monitor the deviation between intention and action, myths, outdated information, misinformation, etc. - Need to cooperate with several units, for example, energy experts and transit operators tend to be unfamiliar with public information, so they need to work with communication experts
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- Public information increases the effectiveness of saving policies by reducing the deviation between intention and action, myths, misinformation, and so on - The effectiveness of public information can increase by interacting with the public and taking advantage of technology to deal with information overloads. The government should both provide and receive information from the public and adjust the enforced policies for a better fit with each group

Note: The information originally comes from the articles listed in Table 4.21 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

4.1.2.11 Policy in General

This section discusses saving policies in general by using 32 articles, and the reviewed articles are presented in Table 4.23. The atmosphere and challenging issues during a crisis are presented along with what the contingency plan should be. The impacts of each measure are likely to be different among income groups, urban settings, and differing situations. Policymakers should pay attention to equity, the most vulnerable households, and interactions among policies. The cooperation between public and private groups, between local and central governments, and among government units is also mentioned. An integrated policy is the key to increasing the effectiveness and sustaining the saving policy in the longer term.

Table 4.23 Data Collection for General Policy

Authors, Year	Areas, Methodology
Anderson, 1983	U.S., Experiences
Banister, 2008	Developed countries and U.K. (London), Literatures and descriptive analysis
Barker, 1983	U.S. (TX, MN, WI, CA, VA, MD, WA, TN, OR, CO, NY), Experiences
Belk, Painter & Semenik, 1981	U.S. (Salt Lake City), Interviews
Brunso, 1983a	U.S. (NY, NJ), Telephone interviews with the top government agency and transit personnel
Brunso, 1983b	U.S., Comments and experiences
Costanzo, Archer, Aronson & Pettigrew, 1986	Unspecified area, Literature on behavioral and social researches
Cox, 1983a	U.S., Experiences
Cox, 1983b	U.S., Experiences
Dare, 1983	U.S. (rural areas), Data and survey on local government
Davis, 1983	U.S., Survey on transit authorities
Frederiks, Stenner & Hobman, 2015	Unspecified area, Qualitative analysis with behavioral economics and psychology
Grischkat, Hunecke, Bohler & Haustein, 2014	Germany, Mobility diaries and in-depth interview

Authors, Year	Areas, Methodology
Hartgen, Brunso & Neveu, 1983	Several cities in the U.S., Studies and Survey in NY
Hartgen & Neveu, 1980	U.S. (NY) Survey on 1,520 New York residents
Humphrey, 1983a	U.S., Interview from the public and private sector
Humphrey, 1983b	U.S., Comments and experiences
International Energy Agency (IEA), 2005b	IEA member countries, Literature reviewed and calculation of cost and impact
Lee, 1983	Australia, New Zealand, U.K., Netherlands, Experiences and literature
Lee-Gosselin, 2010	U.S., Canada, Literatures and shortage simulation
Lyons & Chatterjee, 2002	U.K., Survey conducted right after the crisis ended
Michael, 1983	U.S., Comments and experiences
Nishitateno & Burke, 2014	153 countries including Thailand, Panel data analysis
Noland, Polak, Bell & Thorpe, 2003	U.K. (London, South East, and North East), Telephone survey after the crisis ended for 2 months
Olsen, 1983	U.S. (Washington) Employed a mail survey in the State of during spring 1981 to investigate 6 alternative strategies of promoting energy conservation
Roberts, Vera-Toscano & Phimister, 2015	U.K., Panel data analysis, descriptive analysis, and discrete hazard models
Santos, Behrendt & Teytelboym, 2010	Unspecified area, Literature on policy instruments
Schueftan, 1983	U.S., Studies from DOT based on the interview
Shirley, 1983	U.S., Comments and experiences

Authors, Year	Areas, Methodology
Song, Preston & Ogilvie, 2017	U.K., Data from the Impact of Constructing Non-Motorized Networks and Evaluating Changes in Travel study and mailed survey
Van Malderen, Jourquin, Thomas, Vanoutrive, Verhetsel & Witlox, 2012	Belgium, Data from the home-to-work travel survey and binary choice model
Winkler, 1983	U.S., Experiences

- During a crisis, "panic, confusion", long "lines at gasoline stations" (Humphrey, 1983b, p. 10), protests, and hoarding (Noland et al., 2003) might occur. Citizens are likely to expect their government do something (Schueftan, 1983; Humphery, 1983b).

- It is very important for the government is to "provide accurate, credible, and timely information before, at the beginning, and during an emergency" (Humphrey, 1983b, p. 10). Generally, the government encounters "confusion and concern, lack of funding, lack of personnel, and lack of direction from the Department of Energy" (Shirley, 1983, p. 12). Lack of information is another big problem (Winkler, 1983).

- Consumers tend to respond to a shortage rationally but differently based on "available options, status, ability to respond, the severity of the crisis, and previous investment in actions" (Hartgen et al., 1983, p. 50). Government policies should understand that they are likely to seek a "pain-relieving option rather than any energy-saving" action which the government tries to emphasize (Hartgen et al., 1983, p. 50). Thus, an energy contingency plan that attempts to conserve energy should maintain people's mobility and ensure public confidence (Davis, 1983).

- With the time limits during an emergency, a contingency plan is needed although it is unused regularly (Humphrey, 1983b). The contingency plan should be regularly updated and provide ready responses to implement in a short time when needed (Davis, 1983). It should contain a clear responsibility of each unit (Shirley, 1983; Lee, 1983), have "advance agreements in place with labor, insurance, and fuel supply contractors" (Michael, 1983, p. 13). An effective contingency plan should have related laws and regulations ready to use, accuracy and credibility of public information (Lee, 1983; IEA, 2005b). Participation from citizens to ensure that the public is likely to accept and adopt the policies, monitoring, and assessment are also important. (IEA, 2005b). Furthermore, a good contingency plan requires "consistency between different measures and policy sectors" (Banister, 2008, p. 78) and adaptability (Banister, 2008, p. 79).

- A contingency plan with a "local orientation" is very important because each area has the unique characteristics and problems (Barker, 1983, p. 36; Brunso, 1983a; Schueftan, 1983, p. 70; Davis, 1983). Generally, rural areas do not have sufficient "alternative modes of transportation" and highly rely on "cars or trucks". A crisis has "indirect impacts on rural development, agricultural production, and the quality of life in rural areas" (Dare, 1983, p. 73).

- The governments should respond to the crisis differently among areas (city, suburbs, rural), incomes (low, medium, high), and situations (when the crisis hits, as the crisis subsides, and when the prices rise quickly) (Hartgen et al., 1983). This is because the ability of each measure to cope with the problems in different areas (Humphrey, 1983a; Roberts et al., 2015), different income levels, and different situations tends to be different. High “attention on fuel poverty in rural areas” during price shocks is important (Roberts et al., 2015, p. 222).

- During a crisis, there are concerns about equity effects (low-income, middle-income groups) (Brunso, 1983b). Having more consideration for the elderly, people with fixed-incomes and the poor during a crisis and rising prices (Dare, 1983) is vital. Some single-occupant vehicle drivers shift to transit, but some cannot because of “special requirements” (at least at some point), dependence on cars and their hesitance to shift to other modes (Brunso, 1983b, p. 8). Moreover, policymakers should not forget that “important life changes” (Song et al., 2017, p. 328; Santos et al., 2010) can trigger changes in transportation modes.

- The government should provide a package of economic and transportation supports (Brunso, 1983b; Winkler, 1983, Anderson, 1983), rather than only attempt to conserve fuels. The government should offer alternatives to travel and let people make the decision that best suits their lifestyle and use the mandates and allocation measures for backup strategies (Shirley, 1983). A program to cope with the economic impacts resulting from an energy crisis is needed (Winkler, 1983).

- People are likely to welcome the fuel saving measures and public information (IEA, 2005b). Social norms and people’s beliefs are temporarily changed during a crisis. Car users might perceive some forms of transportation as being more acceptable than during normal circumstances. For example, “taking a bus does not result in a loss of social status during a crisis because other people do so” (Lyons & Chatterjee, 2002, p. 151, Hartgen et al., 1983). However, trust is very important (Lee-Gosselin, 2010).

- The media should “participate in the planning process early” and “a single source of information” is suggested (Humphrey, 1983b, p.10). Involvement from the private sector is needed (Shirley, 1983) as well, because employers are the primary commute creators (Van Malderen et al., 2012). Local governments and industry should work together in developing and implementing the plan (Anderson, 1983).

- Several unfavorable prohibiting measures become more effective during an emergency (Lee, 1983), and can “reduce panic-induced hoarding of gasoline” and the expectation that the government should do something (Schueftan, 1983, p. 70). However considerable explanation is needed for public acceptance (Lee, 1983) along with a huge effort to “monitor and enforce compliance” with the restrictions (Schueftan. 1983, p. 70). However, prohibitive measures gain more public support if the crisis is serious (Olsen, 1983), and if people feel that the proposed policy package works efficiently and is fair for individual drivers and society (Banister, 2008). When public acceptance exists, a policy package gains political acceptability and the desired actions take place (Banister, 2008).

- The synergistic effect of having a combination of measures should be considered (IEA, 2005b). Some policies are more favorable, but have some limitations as mentioned earlier (Schueftan, 1983; Cox, 1983a). Hence, a package of strategies (Davis, 1983; Hartgen & Neveu, 1980; Banister, 2008) or a combination of push and pull measures (Van Malderen et al., 2012; Banister, 2008) should be implemented. The policy package needs cooperation from “employers”, “public and private bus operators”, “ridesharing agencies”, and so on (Cox, 1983b, p. 99). “Advance agreements with labor, insurance, fuel supply contractors” (Michael, 1983, p. 13), and funding sources (Shirley, 1983;

Brunso, 1983a) are important. In addition to the synergistic effect, policymakers and practitioners should monitor the possible negative side effects of each saving policy.

- Although the effectiveness of oil saving is important for policymakers, maintaining mobility (Davis, 1983) and accessibility (Banister, 2008) for all groups are also important. Carpooling, transit, slower driving, and cuts in discretionary travel are promoted and mentioned frequently, but some people claim that significant savings result from fuel-efficient cars available since late 1970s, as consumers want to maintain journey (Hartgen & Neveu, 1980). However, the marginal conserving actions are important because they can maintain mobility for some groups that cannot afford new technology during a short-term crisis. Moreover, a good transportation system in a country can assure that people are protected from a future crisis.

- The improvement for "an integrated transportation system" can make the policies successful (Noland et al., 2003, p. 478). In order to sustain the saving behavior, integrated policy across various forms of transportation, government goals, social groups, and governmental units are the key (Santos et al., 2010).

- Natural environments and other practical concerns should be considered for sustaining more fuel-efficient travel options. The sustained policy programs and policy actions for short-term and long-term car travel are necessary (Lyons & Chatterjee, 2002). Reducing the weak points of the more fuel efficient travel modes help sustain the saving behavior (Grischkat et al., 2014, p. 295).

- Policies regarding "Information and education" are crucial to create behavior change (Santos et al., 2010, p. 78). "Advertising and marketing" (Santos et al., 2010, p.

78) combined with social and behavioral theories aiming to reduce an "attitude-action gap" (Costanzo et al., 1986; Frederiks et al., 2015, p. 1386; Dennis et al., 1990) with regular reminders can increase the effectiveness of disseminating energy saving information and sustain saving behavior. The policy should be more proactive by assisting people to decide which option is best for them. Policymakers should not assume that people can find out by themselves (Banister, 2008).

- The policy should try to take advantage of technology (Banister, 2008). At the same time, policymakers need to be able to capture new influences on saving behavior. For example, fuel-efficient vehicles were claimed to be major saving factors during late the 1970s and early 1980s (Hartgen & Neveu, 1980), but the new technology available today such as electric vehicles might play a major role in a future crisis. New problems might be increasing motorcycle ridership in some developing countries (Nishitateno & Burke, 2014), terrorist attacks in transit systems or power plants, natural disasters caused by climate change, major floods in solar farms, and so on.

- An analysis of saving policies in general is presented in Table 4.24. While section 4.1.2.1 – section 4.1.2.9 focus on the specific issues of each saving policy, this section discusses the policies in the overall picture and focuses on challenging issues during an emergency, synergistic interaction of the policies, and the side effects. In general, this study recommends integrated policies that are tailored to specific segments of the population, as well as tailored information provision.

Table 4.24 Analysis of General Policy

Energy Contingency Plan	General Policy
Pre-implementation activities (Prepare the plan with consideration of the interactions among HO, NE, SE, DE to reach the E4 goals)	- Assess the severity of the situation closely because early detection of the problem can help reduce the negative impacts - With the limitation of time to cope with a crisis, regularly update energy contingency plan; responsibility is designated and assigned personnel/government units are required to be at hand; it is vital to cooperate with private sector, media, local government, and citizens - Public information and all the saving policies should be ready to be implemented to prevent panic, confusion, financial burdens, and other undesirable effects - Set up related agreements, laws, infrastructure, etc. - Update data and prepare special assistance programs for targeted groups
Contribution to maintaining mobility (Provide a more efficient way of travel under E4 perspectives; better understanding and managing HO, NE, SE, DE increase its contribution)	- Despite a crisis and a need to reduce fuel consumption, the saving policies should aim to maintain mobility and accessibility - If prohibiting measures like rationing and driving restrictions are needed, the government should ensure available travel alternatives and options to telecommute and or use compressed workweeks - Infrastructure improvement and development are necessary, but an integrated policy is needed

Energy Contingency Plan	General Policy
Public acceptability/information component plan updates (Understanding the interaction among HO, NE, SE, DE can increase public acceptance)	- Tailored policy design and tailored information increase public acceptance - Transit enhancement and non-motorized modes should be emphasized among those who live near the available infrastructure while carpooling and eco-driving should target those who cannot shift to transit and non-motorized modes such as families with young children, a household that lives far from public transit, and so on - Use social and behavioral theories, goal setting, and tailored information as strategies
Demand restraint potential and implementation time (Less reliance on fuels, maintain economic activities, consider equity, mitigate environmental degradation)	- Implement a package of saving policies simultaneously helps increase the synergistic effects of fuel demand reduction, but mismanagement lessens the demand restraint effect, for example, compressed workweek requires coordination between employers and transit operators to adjust peak hour schedule - Integrated policy increases the effectiveness, for example, bike and ride program allows people who live far from bus stations to leave their cars at home and improve their health simultaneously - Prohibiting measures should be used as a standby for a severe shortage while other measures should be implemented at early stage; some of the policies take time to implement; hence, pre-implementation activities are vital
Funding sources (Economy, equity)	- Public or private funding or the combination of both

Energy Contingency Plan	General Policy
	- Ensure the public funding by creating laws to employ funds for special projects during an emergency - Ensure the private funding by creating laws, agreements and providing some incentives such as tax exemptions, opportunity to advertise products, and opportunity to create a good corporate image
Equity considerations (Equity)	- The governments should respond to the crisis and provide tailored information to appropriate groups at local levels - Policies should target the most vulnerable groups such as seniors, disabled people, the poor, fixed-income groups, people in rural areas
Monitoring, triggering mechanism, institutional/ legal barriers (Monitor all the E4 perspectives with consideration of HO, NE, SE, DE)	- A shortage at a particular level with the expectation of a long duration should trigger the prohibiting measures while rising fuel prices trigger the rest of the measures - Monitor fuel consumption by different trip purposes, income groups, areas, and situations - Monitor the side effects and violations such as safety and tiredness from extended workday policy, illegal taxi from carpooling, covering licensing plate and keeping old cars from driving ban policy, etc. - Monitor the negative interactions among the saving policies such as carpooling that might draw people

Energy Contingency Plan	General Policy
	from non-motorized modes and transit, compressed workweeks that make carpooling harder, etc. - Cooperation with several units, organizational changes, legal requirement, deviation between intention and action, use of technological advancement, etc. can become barriers if the contingency plan is not well prepared
Potential effectiveness/ impact assessments (Effectiveness based on the E4 perspectives with consideration of HO, NE, SE, DE)	- Having the energy contingency plan that is ready to use, setting up agreements and laws, cooperating with private sector, media, citizen and local government, performing preparedness plans, and having integrated policies helps increase the effectiveness - Paying attention to the needs of different social groups, and targeting them with tailored information and channels can improve the effectiveness - Seasonality and natural phenomena can also influence the effectiveness

Note: The information originally comes from the articles listed in Table 4.23 and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

In sum, the first part of this study reviews 150 articles from interdisciplinary fields and categorizes saving policies into 9 measures, which were pricing measures (PM), public transit enhancement (PT), carpooling (CP), telecommuting (TC), compressed workweek (CW), rationing (RT), driving restriction (DR), non-motorized modes (NM), and eco-driving (ED). Each of them has different challenging issues and side effects that policymakers and practitioners need to identify and prepare for in order to minimize adverse impacts and increase the effectiveness. Public information (PI) is a crucial strategy to incorporate with each of the saving policies because of the existence of the deviation between intention and action, panic, confusion, misinformation, mistrust, and information overload. It is suggested using social and behavioral theories and tailored information as strategies. At the end, policy in general (GP) is presented to draw attention to the overall picture and synergistic effects. This section suggests that policies be integrated. Finally, oil saving policies usually aim to reduce the amount of fuel consumed, but maintaining mobility and accessibility are no less important.

4.2 Empirical Study of Gasoline Demand in Thailand

This part employs the econometric methods to examine the correlation between gasoline consumption and other important variables as explained in Chapter 3. Before presenting the results, this section starts with a unit root test and a modeling procedure. Next, the study presents the dynamic model by cointegration technique and then uses simple and asymmetric models. Panel analysis is done first, and time series analysis is done later.

4.2.1 Unit Root Test

Economic time series data generally are non-stationary, so it is important to do a unit root test before modeling. This is to make sure that the data do not create non-stationarity problems which are a series strongly influencing behavior, spurious regressions (high R2 but no relationship), and invalidity of asymptotic analysis. This study employs the unit root test provided in EViews. The Phillips-Perron Fisher test with individual effects as exogenous variables using the Newey-West automatic bandwidth selection and the Bartlett Kernel method is chosen. The test is performed on panel data which have all 5 region cross sections and on time series data of the 5 regions separately. Variables related to prices (GASP, DIESELP, LPGP, NATGASP, VEHP, and TRANSITP), GASQPC, and GDP are the natural log (LN) transformed while other variables are not. Table 4.25 (annual data) and Table 4.26 (quarterly data) show that most of the variables at level data have unit roots, but they do not have unit roots or they are stationary at the 10% level of significance when the first difference is taken. In other words, they are first-order integrated, I(1).

Table 4.25 *P-Value* of the Phillips-Perron Fisher Unit Root Test for Annual Data

Variables Yearly Data	Null Hypothesis: Unit root					
	TH (Panel)	SR	NR	CR	NE	BK
ln(GASQPC)	*0.07*	*0.17*	*0.80*	*0.40*	*0.97*	*0.85*
d(ln(GASQPC))	***0.14***	***0.34***	***0.03***	***0.23***	***0.10***	***0.01***
d(GASQPC)	*0.20*	*0.49*	*0.06*	*0.35*	*0.13*	*0.01*
ln(GASP)	*0.70*	*0.68*	*0.68*	*0.69*	*0.67*	*0.71*
d(ln(GASP))	***0.12***	***0.15***	***0.13***	***0.12***	***0.14***	***0.12***
d(GASP)	*0.41*	*0.43*	*0.43*	*0.41*	*0.26*	*0.44*
ln(GDP)	*0.90*	*0.97*	*0.84*	*0.85*	*0.98*	*0.96*
d(ln(GDP))	***0.02***	***0.00***	***0.01***	***0.00***	***0.02***	***0.15***
d(GDP)	*0.01*	*0.00*	*0.01*	*0.00*	*0.06*	*0.15*
ln(DIESELP)	*0.70*	*0.68*	*0.69*	*0.68*	*0.68*	*0.71*
d(ln(DIESELP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***

Variables Yearly Data	Null Hypothesis: Unit root					
	TH (Panel)	SR	NR	CR	NE	BK
d(DIESELP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(LPGP)	*0.65*	*0.64*	*0.57*	*0.64*	*0.50*	*0.68*
d(ln(LPGP))	***0.04***	***0.05***	***0.04***	***0.05***	***0.05***	***0.04***
d(LPGP)	*0.05*	*0.06*	*0.05*	*0.05*	*0.06*	*0.04*
ln(NATGASP)	*0.92*	*0.87*	*0.88*	*0.92*	*0.85*	*0.96*
d(ln(NATGASP))	***0.21***	***0.22***	***0.20***	***0.21***	***0.21***	***0.20***
d(NATGASP)	*0.30*	*0.30*	*0.29*	*0.29*	*0.28*	*0.30*
ln(OILP)	*0.57*	*0.57*	*0.56*	*0.57*	*0.57*	*0.58*
d(ln(OILP))	***0.02***	***0.03***	***0.02***	***0.02***	***0.03***	***0.02***
d(OILP)	*0.01*	*0.02*	*0.01*	*0.01*	*0.01*	*0.01*
ln(TRANSITP)	*0.64*	*0.68*	*0.47*	*0.42*	*0.34*	*0.65*
d(ln(TRANSITP))	***0.06***	***0.01***	***0.03***	***0.06***	***0.04***	***0.06***
d(TRANSITP)	*0.07*	*0.00*	*0.02*	*0.07*	*0.05*	*0.07*
ln(VEHP)	*0.93*	*0.03*	*0.02*	*0.94*	*0.13*	*0.72*
d(ln(VEHP))	***0.08***	***0.00***	***0.00***	***0.00***	***0.02***	***0.16***
d(VEHP)	*0.08*	*0.00*	*0.00*	*0.00*	*0.02*	*0.16*
ln(NEWVEHQPC)	*0.65*	*0.04*	*0.05*	*0.03*	*0.05*	*0.58*
d(ln(NEWVEHQPC))	*0.03*	*0.13*	*0.15*	*0.15*	*0.34*	*0.01*
d(NEWVEHQPC)	***0.03***	***0.10***	***0.09***	***0.10***	***0.13***	***0.02***
ln(VEHQPC)	*0.63*	*0.97*	*0.98*	*0.97*	*0.95*	*1.00*
d(ln(VEHQPC))	*0.00*	*0.00*	*0.01*	*0.01*	*0.00*	*0.00*
d(VEHQPC)	***0.01***	***0.02***	***0.05***	***0.03***	***0.01***	***0.01***
AGGDP%	*0.98*	*0.99*	*0.67*	*0.96*	*0.02*	*0.84*
d(AGGDP%)	***0.00***	***0.12***	***0.04***	***0.00***	***0.00***	***0.00***
UNEMP%	*0.54*	*0.39*	*0.57*	*0.45*	*0.00*	*0.01*

Variables Yearly Data	Null Hypothesis: Unit root					
	TH (Panel)	SR	NR	CR	NE	BK
d(UNEMP%)	***0.00***	***0.01***	***0.00***	***0.15***	***0.00***	***0.02***
TRANSITQ	*1.00*	-	-	-	-	*0.36*
d(TRANSITQ)	***0.02***	-	-	-	-	***0.00***

Table 4.26 *P-Value* of the Phillips-Perron Fisher Unit Root Test for Quarterly Data

Variables Quarterly Data	Null Hypothesis: Unit root					
	TH (Panel)	SR	NR	CR	NE	BK
ln(GASQPC)	*0.12*	*0.08*	*0.10*	*0.48*	*0.97*	*0.58*
d(ln(GASQPC))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
d(GASQPC)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(GASP)	*0.67*	*0.66*	*0.65*	*0.65*	*0.66*	*0.68*
d(ln(GASP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
d(GASP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(GDP)	*0.87*	*0.94*	*0.65*	*0.78*	*0.96*	*0.95*
d(ln(GDP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.03***
d(GDP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.03*
ln(DIESELP)	*0.60*	*0.57*	*0.59*	*0.57*	*0.57*	*0.61*
d(ln(DIESELP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
d(DIESELP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(LPGP)	*0.34*	*0.33*	*0.27*	*0.33*	*0.27*	*0.40*
d(ln(LPGP))	***0.01***	***0.02***	***0.00***	***0.00***	***0.01***	***0.01***
d(LPGP)	*0.01*	*0.03*	*0.01*	*0.01*	*0.01*	*0.01*
ln(NATGASP)	*0.89*	*0.85*	*0.84*	*0.87*	*0.89*	*0.93*
d(ln(NATGASP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***

Variables Quarterly Data	Null Hypothesis: Unit root					
	TH (Panel)	SR	NR	CR	NE	BK
d(NATGASP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(OILP)	*0.52*	*0.50*	*0.51*	*0.50*	*0.51*	*0.53*
d(ln(OILP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
d(OILP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(TRANSITP)	*0.65*	*0.69*	*0.53*	*0.44*	*0.39*	*0.66*
d(ln(TRANSITP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
d(TRANSITP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(VEHP)	*0.83*	*0.41*	*0.33*	*0.84*	*0.50*	*0.55*
d(ln(VEHP))	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
d(VEHP)	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
ln(NEWVEHQPC)	*0.29*	*0.02*	*0.08*	*0.04*	*0.01*	*0.00*
d(ln(NEWVEHQPC))	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*	*0.00*
d(NEWVEHQPC)	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
AGGDP%	*0.00*	*0.99*	*0.95*	*0.94*	*0.05*	*0.54*
d(AGGDP%)	***0.00***	***0.03***	***0.00***	***0.00***	***0.00***	***0.00***
UNEMP%	*0.12*	*0.00*	*0.00*	*0.10*	*0.00*	*0.01*
d(UNEMP%)	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***	***0.00***
TRANSITQ	*1.00*	-	-	-	-	*0.23*
d(TRANSITQ)	***0.00***	-	-	-	-	***0.00***

4.2.2 Modeling Procedure

The modeling procedure here explains how to add important factors and drop unimportant factors from a model. The modeling procedure is done after the modeling technique is chosen. For example, when a cointegration technique is used, one needs to ensure that the related variables are cointegrated. After that, the modeling procedure is performed. Understanding how the independent variables are viewed is important. They are categorized into 5 groups as stated in Table 4.27.

Table 4.27 Independent Variable Category

Group	Explanation	Independent Variables
1	Main variables	GASP, and GDP
2	Substitute fuels	DIESELP, LPGP, and NATGASP
3	Substitute modes	TRANSITP or TRANSITQ
4	Complementary goods	VEHQPC, NEWVEHQPC, or VEHP
5	Macroeconomic variables	AGGDP%, and UNEMP%
6	Seasonal variables	QUARTER1, QUARTER2, and QUARTER3
7	Other variables	OILSHOCK, TREND, and FLOOD

The first step begins with throwing all variables into the model. For the models with small observations like the time series models with annual data, all variables except for group 7 variables are thrown into the model. The group 7 variables are added in the later stage when some of the other variables are dropped. At the first step, only one of the group 4 variables is included because VEHQPC, NEWVEHQPC, VEHP, and their lags are related to vehicle stock. VEHQPC is selected first, and the lag is chosen based on its correlation with gasoline consumption. When VEHQPC is not available (in models with quarterly data) or when it gives the wrong signal, NEWVEHQPC is selected instead. VEHP is the last choice when NEWVEHQPC does not work because VEHP indirectly relates to gasoline consumption via vehicle stock. TRANSITP is generally used in all models while TRANSITQ was used only in Bangkok where the data is available, but when TRANSITQ is used, TRANSITP is not. When TRANSITP is used, the effect of public transportation is taken into account via transit fares. In contrast, TRANSITQ itself is public transportation ridership, but it does not cover some types of public transportation such as public van riders, taxi motorcycles, jitneys, and so on.

The second step is to drop the group 2 variables with a wrong signal after their transformation to relative prices with gasoline price. Group 7 variables are added in time series annual models where there are small observations when some of the group 2 variables are dropped. Adding group 7 variables at this point should not create the problem of omitting important variables because these variables are not expected to influence gasoline consumption considerably.

The last step is to check the last part of EViews output or goodness of fit of the models, for example, adjusted R2, F-statistic, Durbin-Watson stat, and so on. This step includes the Wald test in an asymmetric model to find the difference between the GASPCUT and the GASPREC coefficients, redundant fixed effects test for panel analysis, endogeneity test for instrumental variable models, and unit root and cointegration test for cointegration models. Please refer to Appendix C for a clearer picture of the modeling procedure.

The next sections present the results from the econometric models by different models, different frequencies of data, and different regions. This section begins with the results from dynamic models and then discusses the results from static and asymmetric models because more related and better findings are gained from the last 2 models.

4.2.3 Results from Dynamic Models (Cointegration Method)

The cointegration technique is performed in annual panel data. Section 4.2.2 has shown that the data are first-ordered integrated, I(1), so the study conducts cointegrating regressions based on the modeling procedure stated in section 4.2.2 and then obtains the residuals from the cointegrating regressions which are expected to present long-run relationships as explained in Chapter 3. The ADF Fisher Unit Root Test finds that one cannot reject the null hypothesis that the residuals are non-stationary at the 5% level of significance (the 5% critical value for the Engle-Granger test of 50 samples and 2 variables is -3.46, and the 5% critical value for the Engle-Granger test of 50 samples and 5 variables is -4.76 (Enders, 2009)). In other words, the variables are not cointegrated and cannot show a long-run relationship. The regression results have the spurious relationship that provides misleading statistical evidence. Another finding that confirms invalidity is the negative coefficients of ECM terms in some equations. The results of cointegrating regressions, unit root testing, and error correction models are shown in Table 4.28. The long-run and short-run relationships found by the cointegration technique were not valid, so they were not used for further analysis.

Table 4.28 Panel Analysis for 5 Regions in Thailand with Annual Data

by Cointegration Technique, Model 1-6

Thailand	Coefficient and *P-Value (in italic)* of Independent Variables					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Sample	2001-	2001-	2003-	2001-	2003-	2003-

Thailand	Coefficient and *P-Value (in italic)* of Independent Variables					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
5 Regions	2015	2015	2015	2015	2015	2015
Long Run	Cointegrating Regression: Dependent Variable = (log(GASQPC))					
C	-7.3154 *0.00*	-8.6174 *0.00*	-14.0027 *0.00*	-12.4826 *0.00*	-11.4199 *0.00*	-19.0520 *0.00*
log(GASP)	-0.6552 *0.00*	-0.7294 *0.00*	-0.5857 *0.00*	-0.4887 *0.03*	-0.5473 *0.00*	-0.5989 *0.01*
log(GDP)	0.8542 *0.00*	0.9715 *0.00*	1.3002 *0.00*	1.2018 *0.00*	1.1250 *0.00*	1.1171 *0.01*
log(DIESELP)				0.0171 *0.95*		0.0076 *0.98*
log(LPGP)		0.1285 *0.59*				
log(NAT GASP)	0.1453 *0.43*				0.0789 *0.77*	
log(TRAN SITP)	-0.0589 *0.74*	-0.0647 *0.69*	0.1034 *0.40*	-0.0798 *0.75*	-0.0103 *0.95*	0.1116 *0.68*
VEHQPC	-2.4836 *0.00*					
VEHQPC(-1)		-2.7811 *0.00*				
log(VEHP)						1.6617 *0.29*
NEWVEHQPC				-4.9901 *0.03*		
NEWVEHQPC (-1)					-6.8800 *0.00*	

Thailand	Coefficient and *P-Value (in italic)* of Independent Variables					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
AGGDP%	-0.0129 *0.21*	-0.0107 *0.29*	-0.0021 *0.87*	-0.0020 *0.86*	-0.0057 *0.73*	-0.0074 *0.62*
UNEMP%	-0.1459 *0.00*	-0.1152 *0.01*	-0.0544 *0.00*	-0.0596 *0.01*	-0.1141 *0.00*	-0.0685 *0.02*
OILSHOCK	-0.0217 *0.15*	-0.0083 *0.64*	-0.0184 *0.26*	-0.0183 *0.31*	-0.0167 *0.37*	-0.0160 *0.38*
TREND	0.0076 *0.41*	0.0108 *0.30*	-0.0204 *0.23*	-0.0129 *0.51*	-0.0138 *0.42*	-0.0226 *0.16*
Adjusted R-squared	0.9935	0.9930	0.9882	0.9886	0.9881	0.9883
F-Statistic	749.4219 *0.00*	702.8516 *0.00*	563.0165 *0.00*	493.909 *0.00*	410.1577 *0.00*	481.5293 *0.00*
DW-Stat	1.0598	1.1738	0.6005	0.6616	0.9194	0.5865
AIC	-2.8001	-2.7363	-2.1981	-2.2125	-2.2016	-2.1873
Redundant CS F-test	69.8233 *0.00*	58.7987 *0.00*	103.3432 *0.00*	39.2881 *0.00*	38.9397 *0.00*	85.6771 *0.00*
CS FE for SR	-0.0169	0.0302	0.2878	0.2426	0.1917	0.1907
CS FE for NR	-0.0623	0.0263	0.4034	0.3076	0.2193	0.2490
CS FE for CR	-0.4826	-0.5809	-0.7117	-0.6795	-0.6211	-0.5532
CS FE for NE	-0.1494	-0.0436	0.4773	0.3578	0.2646	0.2879
CS FE for BK	0.7113	0.5680	-0.4568	-0.2286	-0.0545	-0.1745
ADF Fisher Test	Null Hypothesis: Unit root of residual (individual unit root process)					
Intercept only	-1.4493	-1.9432	1.3194	0.9685	0.5798	1.3347
Intercept and trend	0.3790	0.4039	1.9117	1.9042	0.1762	2.1320

Thailand	Coefficient and *P-Value (in italic)* of Independent Variables					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
None	-4.1186	-4.5155	-2.3773	-2.3870	-2.4341	-1.6250
Short Run	Error Correction Model: Dependent Variable = d(log(GASQPC))					
C	0.0358 *0.26*	0.0798 *0.08*	0.0594 *0.07*	0.0510 *0.05*	0.0692 *0.00*	0.0475 *0.15*
d(log(GASP))	-0.4683 *0.00*	-0.5006 *0.00*	-0.4209 *0.00*	-0.3989 *0.00*	-0.4700 *0.00*	-0.3959 *0.00*
d(log(GDP))	0.2033 *0.41*	0.1319 *0.59*	0.1233 *0.52*	0.0788 *0.68*	0.2203 *0.25*	0.1364 *0.40*
d(log(DIESEL P))				-0.0726 *0.28*		-0.0442 *0.56*
d(log(LPGP))		0.0862 *0.74*				
d(log (NATGASP))	0.0344 *0.81*				0.1150 *0.20*	
d(log(TRAN SITP))	0.1413 *0.03*	0.0883 *0.25*	0.0593 *0.60*	0.1712 *0.09*	0.0348 *0.77*	0.1099 *0.23*
d(VEHQPC)	-1.3011 *0.00*					
d(VEHQPC (-1))		-0.0735 *0.87*				
d(log (VEHP))						0.6034 *0.38*
d(NEWVEHQ PC)				2.6074 *0.00*		
d(NEW VEHQPC(-1))					0.4275 *0.47*	

Thailand	Coefficient and *P-Value (in italic)* of Independent Variables					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
d(NAGRI PROP)	-0.0083 *0.04*	-0.0087 *0.07*	-0.0061 *0.12*	-0.0067 *0.13*	-0.0096 *0.00*	-0.0061 *0.20*
d(UNEMP%)	-0.0651 *0.00*	-0.0750 *0.01*	-0.0215 *0.00*	-0.0216 *0.00*	-0.0920 *0.00*	-0.0224 *0.00*
OILSHOCK	-0.0352 *0.00*	-0.0338 *0.00*	-0.0231 *0.02*	-0.0222 *0.01*	-0.0304 *0.00*	-0.0195 *0.11*
TREND	-0.0002 *0.94*	-0.0032 *0.28*	-0.0019 *0.30*	-0.0015 *0.32*	-0.0030 *0.06*	-0.0015 *0.39*
RESID(-1)	-0.2519 *0.00*	-0.2025 *0.03*	**0.0015** ***0.99***	-0.0483 *0.64*	**0.3000** ***0.00***	-0.0350 *0.64*
Adjusted R-squared	0.6812	0.6524	0.6102	0.6306	0.7455	0.6055
F-Statistic	10.0055 *0.00*	8.9103 *0.00*	10.0021 *0.00*	9.4144 *0.00*	13.3448 *0.00*	8.5641 *0.00*
DW-Stat	1.2912	1.1912	1.5306	1.5087	1.5041	1.4407
AIC	-3.5577	-3.4712	-3.4909	-3.5232	-3.7829	-3.4573
Redundant CS F-test	1.8037 *0.14*	2.9185 *0.03*	3.5938 *0.01*	4.0141 *0.01*	4.9636 *0.00*	3.0422 *0.02*
CS FE for SR	-0.0042	-0.0012	-0.0034	-0.0040	0.0009	-0.0050
CS FE for NR	0.0052	0.0071	0.0078	0.0082	0.0087	0.0071
CS FE for CR	-0.0021	0.0027	-0.0014	-0.0018	0.0059	-0.0016
CS FE for NE	0.0230	0.0264	0.0277	0.0295	0.0216	0.0271
CS FE for BK	-0.0219	-0.0350	-0.0308	-0.0318	-0.0372	-0.0276

4.2.4 Results from Static and Asymmetric Models

Tables 4.25 and 4.26 show that several variables at level have unit roots, but the variables become stationary when the first difference is taken. Also, the variables are not cointegrated. As a result, the study has to rely on the first difference technique to get stationary data. With the first difference, the model contains the first difference of the natural log of GASQPC, GASP, GDP, DIESELP, LPGP, NATGASP, TRANSITP, and VEHP and the first difference of VEHQPC, NEWVEHQPC, TRANSITQ, AGGDP%, and UNEMP%. The first set of variables (the first difference of the natural log) are approximately the percentage changes of these variables while the latter set variables (the first difference only) are the growths or the changes of these variables. Again please note that now the dependent variable is d(log(GASQPC)). The results of the static and asymmetric models start from panel data and then time series data. This section uses the model code with text and number. TH, SR, NR, CR, NE, and BK refer to Thailand, Southern region, Northern region, Central region, Northeastern region, and Bangkok, respectively. Only Thailand is a panel analysis while others are time series analyses. The models presented in Tables 4.29 – 4.35 are selected from Appendix C. Please see Appendix C for more detail.

4.2.4.1 Panel Analysis for Thailand

The panel analysis starts with the model with all variables and non-fixed effect and then examines the model with all variables and fixed regional cross-section effect. Based on a redundant cross-section test, each region is found to be different, but the model can only show the difference at the intercept, not the slope as seen in simple model

4 of the panel analysis for 5 regions in Thailand with annual data and in Table 4.29 and in Table C1 of Appendix C. However, this difference among regions is not significant when quarterly data are used as shown in simple model 3 and simple model 4 of the panel analysis for 5 regions in Thailand with quarterly data in Table 4.30. One of the reasons for this could be the frequency conversion by EViews of some variables, which might lessen the regional difference.

Next, the analysis replaces each independent variable with the set of the regional dummy. In other words, d(log(GASP)) is replaced by d(log(GASP))*DSR, d(log(GASP))*DNR, d(log(GASP))*DCR, d(log(GASP))*DNE, and d(log(GASP))*DBK; d(log(GDP)) is replaced by d(log(GDP))*DSR, d(log(GDP))*DNR, d(log(GDP))*DCR, d(log(GDP))*DNE, and d(log(GDP))*DBK; and this replacement applies to other variables in the model. It is found that each explanatory variable has both positive and negative signs among the regions. Only gasoline price (GASP) has negative signs in all regions. Please see the result in simple model 7 of the panel analysis for 5 regions in Thailand with annual data in Table C2 of Appendix C. With regional dummy sets, a redundant cross-section test from simple model 8 of the panel analysis for 5 regions in Thailand with annual data in Table C3 of Appendix C cannot confirm that the regional difference exists. This is because the regional dummy sets put in each variable already captured these differences. Another modification is to replace the regional dummy set for DIESELP and LPGP only; however, the mixed signs still appear. Although most of the variables find mixed signs among the 5 regions, this fact can imply that each region is unique. More specifically, some fuels are used as substitutes for gasoline in a region, but they not in other regions. Some regions have oil smuggling problems while others do not. Some regions have better developed public transportation than others. With the uniqueness of each region, the study recommends employing time series analysis for the 5 regions separately.

In addition to simple models of panel analysis, TSLS or IV model is conducted, and the Hausman test for endogeneity confirms that GASP is exogenous. In other words, Thailand is a price taker as expected. Thus, the simple models should be employed. TSLS models with OILP as an instrumental variable are shown in Appendix C for reference.

Furthermore, most of the asymmetric models indicate no evidence of the different effect of the increasing and decreasing prices, but the increasing price tends to have a stronger impact on gasoline consumption. However, only asymmetric model 1 of the panel analysis for 5 regions in Thailand with annual data finds a statistically significant difference as presented in Table 4.29.

Table 4.29 Panel Analysis for 5 Regions in Thailand with Annual Data, 2004-2015, Simple Models 1 & 4 and Asymmetric Models 1 & 2

Independent Variables	Coefficient and *P-Value (in italic)*			
	Simple1	Simple4	Asym1	Asym2
C	0.0344 *0.00*	0.0304 *0.00*	0.0529 *0.00*	0.0243 *0.02*
d(log(GASP))	-0.3649 *0.00*	-0.3233 *0.00*		
d(log(GASPCUT))			-0.1873 *0.12*	-0.2823 *0.01*

Independent Variables	Coefficient and *P-Value (in italic)*			
	Simple1	Simple4	Asym1	Asym2
d(log(GASPREC))			-0.6755 *0.00*	-0.4023 *0.00*
d(log(GDP))	0.1991 *0.44*	0.0357 *0.85*	0.0490 *0.82*	-0.0370 *0.84*
d(log(DIESELP))	-0.0890 *0.00*	-0.1137 *0.00*	-0.0388 *0.03*	-0.1346 *0.00*
d(log(LPGP))	-0.1567 *0.49*	-0.0420 *0.89*	-0.2868 *0.33*	-0.0212 *0.95*
d(log(NATGASP))	0.1221 *0.47*	0.1065 *0.55*	0.3313 *0.06*	0.1026 *0.61*
d(log(TRANSITP))	0.2384 *0.00*	0.2630 *0.00*	0.2318 *0.00*	0.2774 *0.00*
d(VEHQPC)	-1.5644 *0.00*	-0.9142 *0.00*	-1.7113 *0.00*	
d(NEWVEHQPC)				1.7e-7 *0.09*
d(AGGDP%)	-0.0087 *0.14*	-0.0087 *0.01*	-0.0059 *0.04*	-0.0064 *0.09*
d(UNEMP%)	-0.0707 *0.00*	-0.0724 *0.00*	-0.0751 *0.00*	-0.0683 *0.00*
OILSHOCK	-0.0423 *0.00*	-0.0381 *0.00*	-0.0326 *0.00*	-0.0252 *0.00*
Adjusted -R2	0.6214	0.6650	0.6897	0.6478
F-Statistic	10.6819 *0.00*	9.3667 *0.00*	9.7427 *0.00*	8.2359 *0.00*
DW-Stat	1.0694	1.2418	1.3262	1.2548

Independent Variables	Coefficient and *P-Value (in italic)*			
	Simple1	Simple4	Asym1	Asym2
AIC	-3.4338	-3.5081	-3.5738	-3.4473
Redundant Cross-section F-test		2.5970 *0.05*	1.8704 *0.13*	4.4441 *0.00*
CS Fixed Effect SR		-0.0050	-0.0066	-0.0042
CS Fixed Effect NR		0.0069	0.0049	0.0079
CS Fixed Effect CR		-0.0006	-0.0033	0.0021
CS Fixed Effect NE		0.0265	0.0245	0.0309
CS Fixed Effect BK		-0.0279	-0.0196	-0.0368
Wald Test (H0: GASPCUT =GASPREC)			*0.00*	*0.31*

Table 4.30 Panel Analysis for 5 Regions in Thailand with Quarterly Data, 2003-2015, Simple Models 1, 3 & 4 and Asymmetric Models 1 & 2

Independent Variables	Coefficient and *P-Value (in italic)*				
	Simple1	Simple3	Simple4	Asym1	Asym2
C	0.0313 *0.04*	0.0320 *0.01*	0.0330 *0.01*	0.0342 *0.02*	0.0351 *0.01*
d(log(GASP))	-0.1953 *0.01*	-0.1936 *0.01*	-0.2164 *0.00*		
d(log(GASPCUT))				-0.1550 *0.04*	-0.1799 *0.02*
d(log(GASPREC))				-0.2295 *0.01*	-0.2502 *0.00*

Independent Variables	Coefficient and *P-Value (in italic)*				
	Simple1	Simple3	Simple4	Asym1	Asym2
d(log(GDP))	0.0358 *0.85*	-0.0382 *0.82*	0.0268 *0.88*	-0.0475 *0.77*	0.0180 *0.92*
d(log(DIESELP))	-0.0197 *0.68*	-0.0197 *0.69*	0.0002 *0.99*	-0.0270 *0.61*	-0.0068 *0.92*
d(log(LPGP))	-0.2689 *0.30*	-0.2609 *0.31*	-0.2529 *0.34*	-0.2562 *0.32*	-0.2485 *0.34*
d(log(NATGASP))	0.2031 *0.00*	0.2044 *0.00*	0.1832 *0.02*	0.2139 *0.00*	0.1923 *0.03*
d(log(TRANSITP))	0.0994 *0.61*	0.1028 *0.62*	0.0892 *0.68*	0.0973 *0.63*	0.0841 *0.69*
d(NEWVEHQPC)	7.6827 *0.01*	7.7305 *0.01*	5.3153 *0.08*	7.6625 *0.01*	5.2556 *0.08*
d(AGGDP%)	0.0047 *0.32*	0.0043 *0.20*	0.0039 *0.18*	0.0042 *0.20*	0.0039 *0.18*
d(UNEMP%)	-0.0049 *0.66*	-0.0046 *0.68*	-0.0072 *0.48*	-0.0054 *0.64*	-0.0079 *0.45*
QUARTER1	-0.0284 *0.28*	-0.0289 *0.28*	-0.0252 *0.34*	-0.0293 *0.28*	-0.0256 *0.33*
QUARTER2	-0.0189 *0.14*	-0.0189 *0.14*	-0.0205 *0.07*	-0.0188 *0.14*	-0.0203 *0.07*
QUARTER3	-0.0531 *0.01*	-0.0531 *0.01*	-0.0549 *0.01*	-0.0534 *0.02*	-0.0552 *0.01*
OILSHOCK	-0.0098 *0.11*	-0.0099 *0.10*	-0.0113 *0.03*	-0.0096 *0.10*	-0.0110 *0.02*
FLOOD			-0.1923 *0.00*		-0.1919 *0.00*
Adjusted -R2	0.2283	0.2237	0.2612	0.2218	0.2593

Independent Variables	Coefficient and *P-Value (in italic)*				
	Simple1	Simple3	Simple4	Asym1	Asym2
F-Statistic	6.7810 *0.00*	5.3042 *0.00*	5.9878 *0.00*	5.0217 *0.00*	5.6797 *0.00*
DW-Stat	2.6383	2.6702	2.5934	2.6751	2.5974
AIC	-3.0338	-3.0131	-3.0590	-3.0071	-3.0529
Redundant Cross-section F-test		0.6375 *0.64*	0.3809 *0.82*	0.6410 *0.63*	0.3839 *0.82*
CS Fixed Effect SR		-0.0022	-0.0028	-0.0021	-0.0028
CS Fixed Effect NR		0.0021	0.0014	0.0021	0.0014
CS Fixed Effect CR		0.0008	0.0002	0.0008	0.0002
CS Fixed Effect NE		0.0076	0.0065	0.0076	0.0065
CS Fixed Effect BK		-0.0084	-0.0053	-0.0084	-0.0053
Wald Test (H0: GASPCUT =GASPREC)				*0.25*	*0.32*

4.2.4.2 Time Series Analysis for 5 Regions

The first difference technique to eliminate the unit root is still used for time series analysis as explained in Chapter 3. Appendix C shows how the modeling procedure is conducted, and then the selected models of each region are presented in Tables 4.31-4.35. The dependent variable here is the growth of gasoline consumption, and its unit is liters per day per person.

To interpret the result, the first group of variables with the first difference of the natural log, GASQPC, GASP, GDP, DIESELP, LPGP, NATGASP, TRANSITP, and VEHP is considered approximately “percentage change”. They are interpreted as the percentage change of gasoline consumption and percentage change of the independent variables. Another group of variables, VEHQPC, NEWVEHQPC, TRANSITQ, AGGDP%, and UNEMP%, have only first differences (without the natural log), and thus they are interpreted as "growth" in vehicles per person, vehicles per person, riders per day, percentage point, and percentage point, respectively. With the log-linear form, a one unit change in the growth of the independent variables generates a (coefficient * 100) percentage change in gasoline consumption.

The TSLS or IV model presented in Appendix C is conducted to find whether gasoline price is endogenous or not. The Hausman test for endogeneity finds that the price of gasoline is exogenous. Therefore, the simple model is better than TSLS with OILP as the instrumental variable. Because time series models are likely vulnerable to autocorrelation and partial correlation problems, Appendix E presents the correlograms of the residuals of the selected models which are shown in Table 4.31 – Table 4.35. All time series models with annual data are free from those problems, but some time series models with quarterly data in some regions have the problems. Thus, the study recommends that time series models with annual data are more valid.

Table 4.31 Time Series Analysis for Southern Region with Selected Simple Models

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple3	Simple5	Simple7
Sample from SR	2004-2015	2003Q2-2015Q4	2003Q2-2015Q4

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple3	Simple5	Simple7
C	-0.0435 *0.12*	0.0070 *0.66*	0.0068 *0.68*
d(log(GASP))	-0.5913 *0.07*	-0.3100 *0.00*	-0.3145 *0.13*
d(log(GDP))	0.0520 *0.95*	0.9773 *0.03*	0.9795 *0.05*
d(log(DIESELP))	0.5930 *0.20*		0.0457 *0.63*
d(log(LPGP)/ log(GASP))			0.0918 *0.92*
d(log(NATGASP))	0.5867 *0.17*		0.0231 *0.85*
D(log(NATGASP)/ log(GASP))		0.0308 *0.93*	
d(log(TRANSITP))	-0.7185 *0.33*	0.0704 *0.69*	0.0796 *0.65*
D(log(VEHP(-3)))			-0.0169 *0.09*
d(VEHQPC(-1))	3.0680 *0.25*		
d(AGGDP%)	0.0298 *0.41*	-0.0031 *0.81*	-0.0014 *0.93*
d(UNEMP%)	0.2162 *0.32*	-0.0376 *0.00*	-0.0386 *0.01*
QUARTER1		0.0371 *0.07*	0.0393 *0.06*

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple3	Simple5	Simple7
QUARTER2		-0.0365 *0.08*	-0.0360 *0.10*
QUARTER3		-0.0258 *0.24*	-0.0218 *0.35*
OILSHOCK	0.0861 *0.17*	-0.0090 *0.31*	-0.0086 *0.34*
Adjusted -R2	0.8684	0.5428	0.5306
F-Statistic	4101.50 *0.00*	14.3897 *0.00*	13.0689 *0.00*
DW-Stat	2.6845	2.5070	2.4159
AIC	-4.5172	-3.6931	-3.6271

Table 4.32 Time Series Analysis for Northern Region

with Selected Simple Models and Asymmetric Model

Independent Variables	Coefficient and *P-Value (in italic)*			
	Annual data	Quarterly data		
	Simple3	Simple4	Simple7	Asym7
Sample from NR	2004-2015	2003Q2-2015Q4	2003Q2-2015Q4	2003Q2-2015Q4
C	0.0318 *0.02*	0.0603 *0.01*	0.0645 *0.01*	0.0800 *0.00*
d(log(GASP))	-0.3889 *0.00*	-0.3958 *0.09*	-0.3575 *0.11*	
d(log(GASPCUT))				-0.1282 *0.64*

Independent Variables	Coefficient and *P-Value (in italic)*			
	Annual data	Quarterly data		
	Simple3	Simple4	Simple7	Asym7
d(log(GASPREC))				-0.6544 *0.01*
d(log(GDP))	-0.4864 *0.12*	-0.3251 *0.62*	-0.4906 *0.43*	-0.4044 *0.51*
d(log(DIESELP))		0.1705 *0.49*	0.2211 *0.38*	0.2432 *0.31*
d(log(NATGASP))	0.3551 *0.04*	0.0464 *0.80*	0.0433 *0.78*	0.1201 *0.49*
d(log(TRANSITP))	-0.0547 *0.68*	-0.0517 *0.91*	0.0289 *0.95*	-0.1355 *0.72*
D(log(VEHP(-3)))			-0.0516 *0.06*	-0.0764 *0.00*
d(VEHQPC(-1))	1.0712 *0.14*			
d(AGGDP%)	-0.0153 *0.05*	-0.0040 *0.78*	-0.0055 *0.69*	-0.0086 *0.55*
d(UNEMP%)	-0.1343 *0.03*	0.0092 *0.82*	0.0161 *0.69*	-0.0005 *0.99*
QUARTER1		-0.0692 *0.08*	-0.0664 *0.09*	-0.0618 *0.10*
QUARTER2		-0.0269 *0.40*	-0.0271 *0.39*	-0.0234 *0.43*
QUARTER3		-0.0839 *0.00*	-0.0726 *0.00*	-0.0724 *0.00*
OILSHOCK	-0.0241 *0.11*	-0.0144 *0.17*	-0.0178 *0.11*	-0.0161 *0.18*

Independent Variables	Coefficient and *P-Value (in italic)*			
	Annual data	Quarterly data		
	Simple3	Simple4	Simple7	Asym7
Adjusted -R2	0.9426	0.3839	0.4125	0.4429
F-Statistic	2239.72 *0.00*	12.0952 *0.00*	15.6453 *0.00*	53.4749 *0.00*
DW-Stat	3.0494	2.2942	2.3023	2.3204
AIC	-5.5403	-2.8480	-2.8823	-2.9229
Wald Test (H0: GASPCUT =GASPREC)				*0.04*

Table 4.33 Time Series Analysis for Central Region with Selected Simple Models

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple3	Simple4	Simple7
Sample from CR	2004-2015	2003Q2-2015Q4	2003Q2-2015Q4
C	0.0490 *0.21*	0.0444 *0.01*	0.0471 *0.00*
d(log(GASP))	-0.1349 *0.13*	-0.1069 *0.45*	-0.0428 *0.58*
d(log(GDP))	-0.2630 *0.30*	-0.8788 *0.04*	-0.8526 *0.03*
d(log(NATGASP))	0.3393 *0.11*		0.0212 *0.85*
D(log(NATGASP)/		0.1017	

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple3	Simple4	Simple7
log(GASP))		*0.85*	
d(log(TRANSITP))	-0.1066 *0.32*	0.5704 *0.05*	0.6245 *0.05*
D(log(VEHP(-3)))			-0.0533 *0.01*
d(VEHQPC)	0.2575 *0.93*		
d(AGGDP%)	-0.0140 *0.77*	0.0861 *0.05*	0.0758 *0.06*
d(UNEMP%)	0.0249 *0.68*	0.0461 *0.39*	0.0462 *0.40*
QUARTER1		-0.0092 *0.67*	-0.0013 *0.95*
QUARTER2		-0.0407 *0.07*	-0.0391 *0.08*
QUARTER3		-0.0741 *0.00*	-0.0654 *0.00*
OILSHOCK	-0.0519 *0.15*	-0.0305 *0.02*	-0.0345 *0.00*
Adjusted -R2	0.8706	0.4625	0.5411
F-Statistic	466.459 *0.00*	10.5420 *0.00*	16.7679 *0.00*
DW-Stat	1.9135	2.4571	2.2104
AIC	-4.4509	-3.3966	-3.5408

Table 4.34 Time Series Analysis for Northeastern Region with Selected Simple Models

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple5	Simple4	Simple7
Sample from NE	2002-2015	2001Q2-2015Q4	2003Q2-2015Q4
C	0.0076 *0.67*	0.0635 *0.00*	0.0580 *0.00*
d(log(GASP))	-0.3778 *0.00*	-0.2175 *0.03*	-0.2066 *0.06*
d(log(GDP))	0.4288 *0.13*	0.7003 *0.21*	0.4899 *0.48*
d(log(NATGASP))			0.0082 *0.97*
d(log(TRANSITP))	0.2972 *0.30*	0.7312 *0.02*	0.9901 *0.00*
D(log(VEHP(-3)))			-0.0419 *0.01*
d(VEHQPC)	3.6869 *0.23*		
d(AGGDP%)	-0.0118 *0.30*	-0.0141 *0.20*	-0.0150 *0.47*
d(UNEMP%)	-0.0298 *0.07*	0.0066 *0.13*	0.0144 *0.32*
QUARTER1		-0.0827 *0.00*	-0.0819 *0.00*
QUARTER2		-0.0174 *0.47*	-0.0142 *0.51*

Independent Variables	Coefficient and *P-Value (in italic)*		
	Annual data	Quarterly data	
	Simple5	Simple4	Simple7
QUARTER3		-0.1014 *0.00*	-0.0770 *0.00*
OILSHOCK	0.0009 *0.96*	-0.0218 *0.15*	-0.0182 *0.16*
Adjusted -R2	0.5528	0.4585	0.4451
F-Statistic	67.0715 *0.00*	6.8610 *0.00*	14.3746 *0.00*
DW-Stat	1.2060	2.5920	2.4646
AIC	-3.4041	-3.0809	-3.0570

Table 4.35 Time Series Analysis for Bangkok with Selected Simple Models

Independent Variables	Coefficient and *P-Value (in italic)*			
	Annual data		Quarterly data	
	Simple3	Simple7	Simple3	Simple4
Sample from BK	2004-2015	2004-2015	2003Q2-2015Q4	2003Q2-2015Q4
C	-0.0529 *0.06*	-0.0692 *0.00*	-0.0150 *0.47*	-0.0144 *0.45*
d(log(GASP))	-0.1585 *0.11*	-0.1885 *0.00*	-0.1351 *0.47*	-0.0668 *0.74*
d(log(GDP))	-0.0468 *0.96*	1.2011 *0.00*	1.0710 *0.15*	0.7501 *0.39*
d(log(DIESELP))			0.1344 *0.38*	0.0712 *0.64*
d(log(LPGP))	0.8140	0.5485	0.6927	0.7567

Independent Variables	Coefficient and *P-Value (in italic)*			
	Annual data		Quarterly data	
	Simple3	Simple7	Simple3	Simple4
	0.07	*0.00*	*0.04*	*0.02*
d(log(TRANSITP))	-0.0584 *0.75*		-0.9016 *0.00*	-0.8358 *0.00*
d(TRANSITQ)		-2.2e-7 *0.00*		
d(VEHQPC(-1))	1.0683 *0.03*	0.5733 *0.00*		
d(NEWVEHQPC)			4.2268 *0.17*	7.4746 *0.09*
d(AGGDP%)	-2.8337 *0.64*	-5.4527 *0.00*	0.5307 *0.89*	-0.3668 *0.94*
d(UNEMP%)	-0.1515 *0.08*	-0.0727 *0.00*	0.0027 *0.95*	0.0155 *0.75*
QUARTER1			-0.0200 *0.48*	-0.0374 *0.26*
QUARTER2			0.0265 *0.19*	0.0299 *0.10*
QUARTER3			0.0137 *0.57*	0.0159 *0.48*
OILSHOCK	0.0020 *0.95*	0.0069 *0.15*	0.0104 *0.43*	0.0134 *0.33*
FLOOD			-0.1603 *0.00*	
Adjusted -R2	0.5595	0.9885	0.2026	0.0543
F-Statistic	43.8381 *0.01*	1571.13 *0.00*	228.556 *0.00*	5.1565 *0.00*

Independent Variables	Coefficient and *P-Value (in italic)*			
	Annual data		Quarterly data	
	Simple3	Simple7	Simple3	Simple4
DW-Stat	2.7137	1.5484	2.3677	2.5525
AIC	-3.7433	-7.3866	-2.8969	-2.7388

- Real Price of Gasoline (GASP; Baht per liter)

The gasoline price of every region has a statistically significant negative correlation with gasoline consumption as expected, and it is inelastic. The coefficient of yearly data ranges from (-0.13) to (-0.59) while the coefficient of quarterly data ranges from (-0.04) to (-0.40). The quarterly models show less sensitive effects of the price than the yearly models. The reason for this could be that consumers take time to find ways to adjust their behavior. Southern and Northern regions tend to be more responsive to the price change while Central region and Bangkok tend to be less responsive even though Bangkok and its vicinity have better transit development. Perhaps the quality of the transit is not good enough to significantly attract car users to switch when gasoline prices increase.

For the yearly model, a one percent change in the increase of gasoline prices will cut back the consumption by a 0.59 percent change approximately in the Southern region, by a 0.39 percent change approximately in the Northern region, by a 0.13 percent change approximately in the Central region, by a 0.38 percent change approximately in the Northeastern region, and by a 0.19 percent change approximately in Bangkok. Compared with time series analysis by region, simple model 4 of the panel analysis for 5 regions in

Thailand with annual data provides the coefficient of -0.32 and simple model 1 of panel analysis for 5 regions in Thailand with quarterly data provides the coefficient of -0.20.

Increasing price is likely to affect gasoline consumption more sensitively than decreasing price as found in the literature mentioned in Chapter 2, but the difference is not statistically significant. Only the Northern region with quarterly data finds the statistical difference between the effect of decreasing price and the effect of increasing price, as shown in asymmetric model 7 of the time series analysis for the Northern region with quarterly data in Table 4.32, and the increasing price generates a stronger impact. This means that a reduction in gasoline consumption during an increasing price is larger than an increase in gasoline consumption during a decreasing price.

- Per Capita GDP (GDP; Baht per person)

The results show mixed signs and several of them are not statically significant at 5%. GDPs in the Southern and Northeastern regions positively correlate with gasoline consumption as expected while GDPs in the Northern and Central regions negatively correlate with gasoline consumption. The Central region result is surprising since the region has areas contiguous with other regions. People drive in and out of or pass through the Central region to their destinations in other regions. However, the unexpected result in the Northern region shows that gasoline is an inferior good. Air travel may be the choice that people select when they have higher incomes. However, this is not quite clear. The impact of low-quality tourism and other factors may be reasons for this as well. Thus, more studies are needed. However, the correlation is not statically significant. For Bangkok, a yearly model without public transportation ridership also finds a negative correlation, but it is not statistically significant. However, other Bangkok models confirm that GDP positively correlates with gasoline consumption.

- Substitute Fuels: Real Price of Diesel (DIESELP; Baht per liter), Real Price of Liquefied Petroleum Gas (LPGP; Baht per liter), and Real Price of Natural Gas for Vehicle (NATGASP; Baht per kilogram)

Diesel is found to be a substitute fuel in the Southern region, Northern region, and Bangkok, but it is not in the Central and Northeastern regions. LPG is not found to be a significant substitute fuel in any region except for Bangkok whereas NGV plays an essential role in several regions except for Bangkok and the Northeastern region. This implies that each region has different consumer behavior, different characteristics and different infrastructures such as availability of LPG/NGV service stations and installation. However, the areas which are not found to be influenced or insignificantly influenced by these 3 substitute fuels might actually be impacted by the 3 fuels at some point for a short time. It is too early to conclude that Diesel, LPG, and NGV never or do not affect gasoline consumption, especially when prices of gasoline are high and prices of the substitute fuels are capped. More information is presented in the next section.

- Substitute Mode: CPI of Public Transportation (TRANSITP), and Public Transportation Ridership (TRANSITQ; Riders per day)

The study initially hypothesizes that TRANSITP has a positive correlation with gasoline consumption. In other words, higher bus fares discourage bus ridership and cause a switch to private cars. This is true for the Northeastern region (based on the time series analysis) and the country as a whole (based on the panel analysis) while

TRANSITPs in Bangkok and other regions have an insignificant negative correlation with gasoline consumption. Obviously for Bangkok, this is because several public transportation projects have been developed during the last 2 decades. The higher fares of BTS and MRT do not discourage people from riding the metro trains because of their better quality and avoidance of traffic congestion. This evidence shows that if the country improves public transportation and people gain better benefits from it, they are willing to pay more. However, the Southern, Northern, and Central regions show confusing results as the quarterly models tend to show positive correlations whereas the yearly models tend to show negative correlations. However, most of the correlations are insignificant at the 5% level.

TRANSITQ is another proxy to present public transportation ridership, but the limitations of having TRANSITQ are annual data availability only in Bangkok and the exclusion of some public transportation such as jitneys, public vans, and so on. For Bangkok, higher public transportation ridership significantly reduces gasoline consumption.

- Complementary Goods: Vehicles Per Person (VEHQPC; Vehicles per person), New Vehicles per Person (NEWVEHQPC; Vehicles per person), and CPI of Vehicle Purchase (VEHP)

VEHQPC is found to be an important factor in yearly models, but VEHP tends to show a more apparent impact in quarterly models except for Bangkok where NEWVEHQPC significantly influences gasoline consumption in the quarterly model. In yearly models, the Southern region, Northern region, and Bangkok employ a 1-year lag (t-1) of VEHQPC while other regions use the current period (t) of VEHQPC. In quarterly models, all except for Bangkok use VEHP with 3 quarters lag.

In annual models, VEHQPC in the Central region and Bangkok tends to show a weaker influence on gasoline consumption compared with other regions. An increase in the growth of vehicles by 1 vehicle per person (or by 1 vehicle per 1,000 persons) will raise gasoline consumption by a 100-300 percent change (or by a 0.1-0.3 percent change) approximately in the Southern, Northern, and Northeastern regions, and will raise gasoline consumption by a 26-57 percent change (or by a 0.026-0.057 percentage change) approximately in the Central region and Bangkok. In quarterly models, VEHP in the Southern region tends to show a weaker impact on gasoline consumption compared with the Northern, Central, and Northeastern regions.

- Macroeconomic Variables: Proportion of GDP from the Non-Agricultural Sector over Total GDP (AGGDP%), and unemployment Rate (UNEMP%; Percentage)

The Northern region, Northeastern region, and Bangkok find negative correlations between AGGDP% and gasoline consumption even though most of them are statistically insignificant. This might imply that industrialization (or moving away from the agricultural economy) in the regions leads to urban planning or land use changes in a way that decreases gasoline consumption. However, AGGDP% in the Southern and Central regions shows mixed signs of correlation. For the Southern region, this might be because oil smuggling from Malaysia generates an inaccurate demand for gasoline. For the Central region, the reason might be its location, which connects with all other regions. The traffic in the region is not only created by people in that region but is also created by people from other regions; consequently, the effect of land use changes might be lessened.

In yearly models, UNEMP% is likely to have a negative correlation with gasoline consumption as expected while quarterly models provide opposite results. However, the Southern and Central regions again by yearly models reveal positive relationships which are counterintuitive. The study recommends using yearly models for UNEMP% because the seasonal effect might not be totally eliminated by seasonal dummy variables, and unemployment in Thailand is heavily influenced by agricultural seasons. For the national level based on the panel analysis, a reduction in gasoline consumption is associated with an increase in UNEMP%.

- Seasonality: First Quarter (QUARTER1), Second Quarter (QUARTER2), Third Quarter (QUARTER3)

Based on the panel analysis with quarterly data in Table 4.30, the fourth quarter is the peak for the country's gasoline consumption while the third quarter tends to be the lowest consumption period. However, there are some interesting variations among the 5 regions.

Like the data at the national level, the fourth quarter is the peak for gasoline consumption in the Northern, Central, and Northeastern regions as it is the harvesting and holiday season when people go back to their hometowns and travel in these areas. In contrast, the fourth quarter is the lowest period of gasoline consumption in Bangkok where people from upcountry come to work and go out during their harvesting season, and Bangkokians themselves travel to other areas during the holiday season. Second and third quarters are the peak for gasoline consumption in Bangkok but are the lowest period for gasoline consumption in the other 3 regions as they are the summer and rainy seasons in Thailand.

The Southern region has a different seasonality effect compared with other parts of the country because of its different climate, in which the rainy season lasts until December. The first quarter is the peak for gasoline consumption, and this period is also the peak season for the tourism industry, especially on the Andaman coast. The lowest periods of gasoline consumption in the Southern region are the second and third quarters.

- Other Variables: Oil Shock by Excess Demand (OILSHOCK), and Flood in Quarter 4/2011 (FLOOD)

Oil shocks sometimes occur for a few weeks or months. The quarterly models should have a higher ability to explain the impacts of these shocks. The quarterly panel analysis finds a negative effect as expected. This indicates that during a crisis, there might be a feeling of altruism, self-awareness and the need to save costs. For yearly time series models, the Northern and Central regions find a negative correlation, but the effect in the Southern region is positive. The reason for this might be oil smuggling from Malaysia where oil prices are subsidized. During times of high oil prices, there is a greater incentive to smuggle from Malaysia; however, at some point, the Malaysian government strictly enforces the law curbing cross-border smuggling to the Southern region of Thailand. Surprisingly, the effect of shocks in Bangkok and the Northeastern region is positive even though the result is insignificant. The lighter traffic in the areas during a high oil price period might encourage those who are able to pay to speed up and consume more gasoline. However, the reason behind this should be researched, and the result should warn policymakers to revise energy conservation campaigns more effectively.

The flood in the last quarter of 2011 in Bangkok was an important factor which should be included in the model. The dummy variable improves goodness of fit of the model. Compared with the model without FLOOD, the model with FLOOD shows higher influences of gasoline price and GDP on gasoline consumption.

4.2.5 Substitute Fuels

As mentioned earlier, it is too early to infer that the substitute fuels do not play a role at some point in time even though the econometric method cannot confirm their influence. Table 4.36 shows that LPG actually plays a role in the transportation sector even though the yearly models in several regions do not find the substitution effect. LPG consumption increases as the crude oil price increases, and it reached its peak in all regions during 2008 when the crude price hit new highs. This evidence does not say that the econometric method should not be used, but interpretation and adjustment for particular situations are very important when ones utilize a model. In this case, the effect of LPG during the high oil price might blend in the shock dummy variable. In the future, new fuels, new technologies, new infrastructures, etc. will also need careful adjustments and additional information for better understanding of consumer behavior.

Unlike LPG, Diesel consumption during the high oil price period in 2008 did not increase when the crude price increased as presented in Table 4.37. In other words, the substitution role is not found to be significant. It is possible that some gasoline consumers switched to diesel because gasoline prices in Thailand were lower and less subsidized than diesel prices. However, some diesel consumers conserved more during the high oil price period. As a result, the substitution role was offset and became unobvious.

Table 4.36 LPG Consumption in Transportation Sector

and High Oil Prices during the 2000s

Year	LPG Consumption in Transportation Sector (liter per person)						Brent Price (USD/ Barrel)
	SR	NR	CR	NE	BK	TH	
2005	0.09	0.02	7.57	0.29	58.37	8.75	54.57
2006	0.16	0.33	13.19	0.72	79.45	13.19	65.16
2007	1.02	2.45	16.34	1.28	86.92	16.34	72.44
2008	2.35	6.62	22.04	2.92	96.94	22.04	96.94
2009	3.27	5.81	18.83	3.56	76.90	18.83	61.74

Source: Department of Energy Business, 2017

Table 4.37 Diesel Consumption in Transportation Sector

and High Oil Prices during the 2000s

Year	Diesel Consumption in Transportation Sector (liter per person)						Brent Price (USD/ Barrel)
	SR	NR	CR	NE	BK	TH	
2005	155	124	268	76	251	164	54.57
2006	156	124	264	83	256	167	65.16
2007	150	121	251	85	254	164	72.44

2008	150	126	241	94	232	163	96.94
2009	151	134	234	102	214	164	61.74

Source: Department of Energy Business, 2017

4.2.6 Subsidies and Switching to Different Grades of Gasoline

The economic method used in the second part of this study views gasoline consumption overall. This includes petroleum gasoline and various grades of gasohol. This section points out that within the gasoline market with different grades of gasoline and gasohol, price incentives cause switching from gasoline to gasohol. Besides excise taxes, the oil fund is often used to stabilize oil price, reduce negative economic impacts, and promote renewable energy.

Table 4.38 explains that the oil fund is successfully used to promote gasohol. Petroleum gasoline is taxed considerably higher than gasoline, and some grades of gasohol are subsidized. The price incentive leads to a switch from petroleum gasoline to gasohol. Another vital policy was to phase out gasoline octane 91 in 2013.

Table 4.38 Oil Fund and Gasoline Consumption

Year	Oil Fund (Baht per liter)						Consumption (Litter per day per person)	
	Petroleum Gasoline		Gasohol					
	95	91	95E10	91E10	E20	E85	Petroleum Gasoline	Gasohol
2005	1.28	1.03	0.13	0.16			0.28	0.03
2006	2.70	2.50	0.84	0.84			0.25	0.05
2007	3.67	3.37	0.85	0.62			0.24	0.07
2008	3.78	3.31	0.77	0.28	-0.21		0.16	0.05
2009	6.94	5.31	1.78	1.17	-0.80	-7.88	0.13	0.19
2010	7.50	6.65	2.74	1.43	-0.41	-10.93	0.13	0.18
2011	4.90	4.38	1.87	-0.40	-1.80	-13.50	0.13	0.17
2012	5.23	4.73	2.03	0.16	-1.30	-12.40	0.13	0.18
2013	9.57	6.42	3.41	1.27	-1.08	-11.43	0.03	0.31
2014	10.00		3.69	1.73	-0.40	-10.34	0.02	0.35
2015	6.85		1.04	0.51	-1.49	-7.91	0.02	0.37

Source: (Energy Policy and Planning Office, 2016)

Another point which can be seen from Table 4.38 is that the oil fund (for gasoline and gasohol E10) tends to reduce, and subsidies (for gasohol E20 and E85) tend to increase during the high oil prices in 2008, 2011, and 2012. Although the strategy can cut back the influence of high oil prices, the effectiveness of the oil saving policies is lessened. It is likely for gasohol consumers to think that they can take advantage of gasohol subsidies and take oil saving behavior less seriously.

The econometric method used in this part of the study provides useful information for policymakers. The direction and correlation of each factor are observed. One of the most important things found is that each region/area is unique. As mentioned in the analysis in section 4.1.2, when making the national oil saving policies, policymakers should identify important details at regional or provincial levels in order to make the policies more effective. Moreover, all econometric estimations should be carefully interpreted and carefully adjusted for each particular situation because each crisis and the conditions at that time are different. For example, if a crisis hits in the first quarter when it is the peak time for the Southern region but the lowest for Bangkok, attention on Bangkok can be slightly reduced if the crisis does not last long. However, policymakers should consider how to considerably increase awareness of oil saving because of the lower responsiveness to price changes and the positive oil shock dummy result. More attention on the Southern region is needed, and more data should be collected and considered. The shock can hurt the tourism industry during its high season, and oil smuggling from Malaysia can be aggravated. The first quarter of a given year might not be the peak of gasoline consumption; the peak might switch to Bangkok as domestic tourists stay in town. In other words, the travel patterns of the two regions might change. Even though the econometric method is useful, several adjustments and considerations are very important when policymakers utilize the information from the econometric method.

4.3 Oil Saving Policies for Thailand

This section focuses on oil saving policies within the context of Thailand. First, the data from comments based on the Pantip online discussion forum are presented for each oil saving policy. Second, the information from articles and government documents is presented. Third, to generate oil saving policies for Thailand, the study discusses and compares the important points found in section 4.1 (oil crises and oil saving policies), section 4.2 (The empirical study of gasoline demand in Thailand), and the online discussion forum and government documents in section 4.3 (oil saving policies for Thailand). Finally, the study identifies what policymakers need to do to improve the efficiency of each oil saving policy. The analyses of each saving measure in section 4.1.2 are still useful for Thailand and should be considered. However, the recommendations for policymakers presented here emphasize the important points for Thailand which differs from other countries and with which the country needs to concern itself more. The crucial points from the tables in section 4.1.2 need to be adjusted to a better fit for Thailand.

4.3.1 Pricing Measures

4.3.1.1 Results from the Online Discussion Forum

More than 2,000 threads are talking about high oil prices. Several threads discuss how the high oil prices affect Thailand's stock market. 22 threads are related to pricing measures and government actions. The comments from the 22 threads are grouped as follows:

Expectations about prices in the future:

- Prices of oil have been low during the last few years. Several people believe that oil prices will not be high again because of new technology and environmental threats. In contrast, others believe that anything can happen, that oil prices can be high again, and that the renewable energy technology and electric vehicles available now are not competitive with oil and its technology.

Plans to respond to high oil prices in the future:

- Some people say that a price rise of 5 Baht/liter will not reduce oil consumption much because people need to drive due to the distance they live from where they work and the lack or infrequent service of public transit in those areas.

- If oil prices increase by 5 Baht/liter, some people will switch to alternative fuels like NGV or LPG as they did in last decade’s crisis. The hybrid car is another option.

- If oil prices increase by 5 Baht/liter, people who do not drive a lot will not change their behavior much. Some people mentioned that it will not be a major concern. They made it through previous difficult periods and they expect to do so again if need be.

Options to travel:

- Poor public bus service, limited networks, and high metro rail fares give some people no choice, and they have to drive even in times of oil price increases. It becomes cheaper to commute by car or taxi if there are more than 2 people.

- Because cars also show status and position, some people still feel compelled to use them.

Opinions on oil subsidies and taxes:

- If oil prices increase by 5 Baht/liter, people would still drive because the government would subsidize some fuels such as diesel and some grades of gasohol as it did last decade.

- If oil prices increase considerably, the government should reduce oil taxes to help reduce the impact. Some people do not agree that the government should float oil prices when the prices are very high. They believe that the government or PTT (the former oil state enterprise) should take any action necessary to stop or mitigate the rise of oil prices.

- Some people believe that subsidizing diesel is crucial because it can mitigate the impacts on the agricultural sector, public transportation, and the poor. However, some people feel that it is unfair to subsidize one fuel by using revenues from taxing another fuel. The government usually floats high-grade gasoline and subsidizes diesel and gasohol. Price mechanisms should not be distorted.

- Some people do not agree with fuel subsidization because of the distortion and higher taxes for other fuels. People agree with high oil taxes if the country uses the tax revenues to improve public transit and other projects efficiently or support the agricultural sector.

- Some people do not agree with high oil taxes because they believe that the government and public transit cannot manage the budget efficiently. Moreover, high oil taxes have a disproportionate negative impacts on middle and low-income people.

- Some people understand that the oil fund is used to stabilize oil prices and promote renewable energy, but some people feel that the tax is too high and leads to high retail oil prices.

Concerns about high oil prices and political issues:

- High oil prices lead to concerns about higher food prices and living costs, but a reduction in oil prices does not lead to lower living costs.

- Because of political unrest and the yellow and red clash (the division of the 2 groups using the colors as their symbols), oil prices, taxes, crude exports and PTT reform are important issues causing distrust and attacks against the government or opponents. These political conflicts between the 2 groups already cause each to judge their opponents. They do not look at the facts and figures related to oil prices and interest groups from the other side. Some people do not trust the government, Ministry of Energy, and PTT.

- When oil prices are high, people pay attention to the comparison between the prices that Thai people pay and the prices that people in other countries pay, and the comparison of the proportion of expenses on oil. People question if they are treated fairly by their government.

- People want the government to actively explain more on how oil prices are structured and taxed, and on the comparison with prices in other countries. Most people do not know these facts. Some people do not believe the data distributed by PTT.

4.3.1.2 Information from Articles

Price controls and politics

Before price deregulation in 1991, Thailand's ex-refinery prices were announced dependent on the oil market in Singapore without a clear formula setting (National Energy Policy, 1995). With price controls, Thailand encountered physical shortages during oil crises in those days. The first shortage occurred during World War II and caused the Fuel Allotment Act of 1940 (B.E. 2483) to be legislated. During the 1973 and 1979 crises, the reduction in oil production from OPEC countries was one reason for the oil shortage, but another important reason was the price control policy at that time. The government tried to delay each price adjustment; however, oil importers and traders did not want to sell the products more cheaply than the price it cost them to import or refine them (Wisansuwannakorn, 2006). The Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516) and the oil fund also originated during the price control policy. The oil fund has been used to subsidize oil prices since the 1979 crisis. Although the government attempts to control the prices, they have had to adjust the prices several times. They explain the necessities of increasing the prices. However, the opposition party and several protest groups feel that the government cannot solve the problem efficiently (Wisansuwannakorn, 2006). Besides shortages and protests after adjusting the prices, during the period of the price control policy, the country encounters hoarding of several commodities, a black market for lower oil prices, low quality of petroleum products, an increase in public transportation fares, and inefficient oil consumption (Wisansuwannakorn, 2006).

Subsidy, politics, and satisfaction

After August 1991, petroleum prices were deregulated, and the price formulae were revised by linking the oil prices of the previous week in Singapore market (National Energy Policy, 1995). The 1999-2000 crisis was aggravated by Baht depreciation. The government assisted only specific groups such as fishermen and farmers although the government implemented other oil saving policies. The effects of high oil prices led to criticism from the opposition party and people who felt that the government did not do enough and the government lost its popularity in the next election (Wisansuwannakorn, 2006). Although oil prices in Thailand are deregulated, the government intervened with high oil prices during the 2000s and the 2010s through the oil fund and oil excise taxes. During high oil prices in 2004-2005, the oil fund was used to subsidize prices. The government spent 92,071 million Baht during the 1.5 years (Energy Policy and Planning Office, 2005) excluding the loss of tax revenue from a reduction in oil excise taxes and municipal taxes (Tangkitvanich & Kansuntisukmongkol, 2007) which was implemented to mitigate the negative impacts of high oil prices on the economy and consumers (Office of Industrial Economics, 2008). LPG and NGV began to play an essential role during the crisis (Koomsup and Sirasoontorn, 2007). High oil prices in 2007 and 2008 were also managed by the oil fund. Figure 4.1 shows that oil taxes and the oil fund (blue area) were reduced, especially during the third quarter of 2008 (Energy Policy and Planning Office, 2009) when oil prices peaked. Diesel, gasohol, LPG, and NGV prices were subsidized. However, the subsidies led to a distortion in which diesel consumption was higher than it should have been because diesel was more heavily subsidized than gasohol, and NOx, CO, and SO2 increased (Tangkitvanich & Kansuntisukmongkol, 2007).

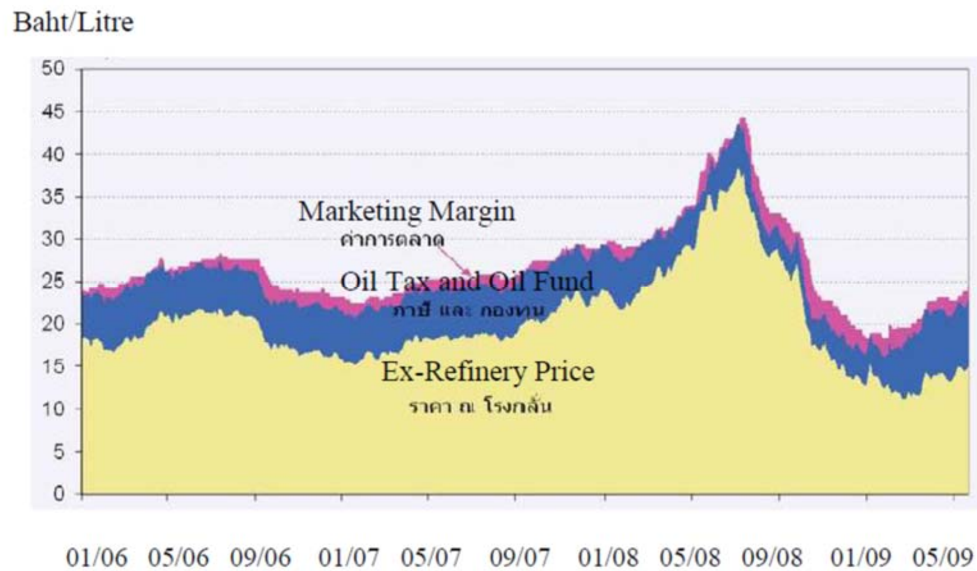

Figure 4.1 Retail Fuel Prices Consisting of Ex-Refinery,

Oil Tax and Oil Fund, and Marketing Margin

Source: Energy Policy and Planning Office, 2009

Substitute fuels and own price inelasticity

Although gasoline is not subsidized as heavily as diesel, some gasohol grades are subsidized and become cheaper options for consumers. Diesel, NGV, and LPG are alternative fuels for gasoline; however, a government survey indicates that in some areas biodiesel, gasohol, NGV, and LPG are not sufficiently available for consumers (National Statistical Office, 2007). Moreover, about 59% oil consumers are not sure about gasohol's impact on their cars, 7% feel that gasohol makes the engine defective, and 2% feel that gasohol runs out too fast (National Statistical Office, 2007).

4.3.1.3 Pricing Measures for Thailand

Discussion of the information found in sections 4.1-4.3:

- The information from the online discussion forum asserts the negative but inelastic correlation between gasoline price and gasoline consumption presented in section 4.2. Based on the evidence found by other studies in section 4.1, the inelasticity of gasoline price in Thailand is not much different from the inelastic price of other countries (Adom et al., 2016; Burke & Nishitateno, 2013; Dahl & Sterner, 1991). In section 4.2 the Central region and Bangkok are found to have consumption that is less sensitive to gasoline price than in other regions. This is consistent with the comments on the online discussion forum mentioning that people have no other good choices of transportation and they live far from where they can easily access the kind of public transportation provided in the capital city. In other words, public transit availability might not always increase price elasticity if the service is not good enough, the fare is high, connectivity is poor, frequency and punctuality are low, and safety is questioned. For other regions with higher price sensitivity, it cannot be confirmed that the reduction in gasoline consumption does not lead to significant difficulties because of limited information.

- Section 4.1 does not provide details about substitute fuels in other countries, but the evidence from the online forum mentions several of them. However, a government survey reveals that in some areas the substitute fuels are insufficiently available for consumers (National Statistical Office, 2007), and section 4.2 shows that some of the substitute fuels do not significantly correlate with gasoline consumption. Hence, not everyone can quickly adjust to those substitute fuels even though they are cheaper.

- Unlike the evidence found in developed countries presented in section 4.1, the comments from the online forum show that many Thai people expect the government to subsidize fuel prices, especially during a crisis. In the past, price controls were used in several countries, and shortages occurred because the policy discouraged oil producers and importers from producing and importing more (Brunso, 1983b; Lee, 1983) as mentioned in section 4.1. This is found in Thailand as well because oil traders do not want to sell for a greater loss (Wisansuwannakorn, 2006). Although oil prices have been fully floated since August 19th, 1991, subsidizing some fuels still exists. Experiences from the past as found in the articles show that despite having price subsidies, some groups of people and opposition parties criticize the government for not doing enough (Wisansuwannakorn, 2006). If oil prices are not subsidized during a crisis, the government will lose its popularity. With weak institutional capacity and political instability in Thailand, subsidizing for the poor and stabilizing the price for everyone are likely to occur during a crisis even though fuel subsidies generate many negative impacts including on oil saving policies.

- Different from other countries, Thailand has several grades of gasoline and gasohol is usually subsidized as seen in Table 4.38 (Energy Policy and Planning Office, 2016) in section 4.2. People think that it is unfair to subsidize gasohol by taxing petroleum gasoline consumers. To make matters worse, gasohol consumers might feel that they have the opportunity to use the cheaper subsidized fuel, so they do not need to reduce their consumption seriously. This thought also applies to diesel, NGV, and LPG which are usually subsidized during a crisis. Not only are equity and energy goals shaken, but environmental damage is also continued.

- Another issue found in the context of Thailand is distrust in the government. Although there are attempts to mitigate the negative effects of high oil prices via subsidies, opinions from the online discussion forum show that many people are not satisfied with the system, and politics are frequently involved with the government's decisions. Distrust and a need to understand oil price structures are stated in several comments on the online discussion forum too.

- As mentioned in section 4.2 that gasoline consumption is more sensitive when the price is increasing, and the effect of the price shock is significant at the national level, the online discussion forum shows that Thai people try to find ways to save travel costs. However, the sensitivity and the shock effect should be higher if all the fuel prices are not subsidized. In other words, subsidies lead to a less efficient reduction in consumption. Another point found in section 4.2 is the insignificant positive relations between the shock dummy and gasoline consumption in the Southern region, the Northeastern region, and Bangkok. Smuggling from Malaysia and the inability to smuggle at some point might lead to an increase in gasoline consumption during a crisis. The lighter traffic in Bangkok and the Northeastern region during a high oil price period might encourage those who are able to pay or those who are not responsible for the cost (such as company drivers, executives who can reimburse fuel expenses, etc.) to drive at higher speeds, cancelling out the effect of altruism during a crisis. However, more research should be done, and the government should revise its oil saving campaigns, especially in Bangkok and the Northeastern region.

- The information found from section 4.2 is regionally disaggregated by regions, but the information from both section 4.2 and section 4.3 does not observe the differences in gasoline consumption among different groups using factors such as socioeconomic variation (Dahl, 2012; Dillon et al., 2015) sociodemographic characteristics (Dillon et al., 2015), and purposes of trip (Guirao et al., 2016) as suggested in section 4.1. These variations should be further researched in order to match campaigns and assistance to the right groups.

Recommendations for policymakers:

- Pre-implementation period

- The country should eliminate the fuel subsidy gradually during a time of low oil prices, and provide assistance for targeted groups if necessary. Removing fuel subsidies during a period of high oil prices will generate widespread protests (Soile & Mu, 2015). Because the compensation mitigating the impacts of price shocks varies among groups, disaggregated assistance and tailored strategies are more effective (Rentschler, 2016)

- The government should collect and regularly update data of the vulnerable groups which need quick attention if a crisis occurs. The data categorize socioeconomic variation, sociodemographic characteristics, and trip purposes to match campaigns and assistance to the right groups. For example, the urban poor might prefer assistance regarding public transit accessibility while the rural poor who live far from public transit might prefer having a safer biking environment, but the rural poor in the Northern regions living near hills and mountains might prefer carpooling to biking.

- Because fuel subsidies bring several negative impacts which obstruct the country from reaching energy, economy, equity, and environment goals, the country should not allow subsidization of fuel prices (non-targeted subsidies) during a crisis regardless of the reasons to assist the poor, stabilize the price of economy, and promote renewable energy. Setting up regulations that prevent future fuel subsidization during a crisis is essential because Thailand is likely to stabilize fuel prices during a crisis.

- Without subsidies, the government needs to provide assistance to mitigate the negative impacts of a crisis, but the assistance must incentivize private car drivers to switch to more fuel-efficient forms of transportation (such as carpooling, public transit, non-motorized modes) and support other oil saving measures (such as working from home and using the compressed workweeks). This kind of assistance helps the government maintain popularity and encourages people to save energy actively at the same time. In other words, the assistance needs to consider the objectives of mobility and oil saving while subsidies achieve only mobility objectives which would not reach the E4 goals. The funding sources of the assistance can be both public and private forms to reduce impact on the government budget. The government assistance plan should contain details such as cooperation with the private sector, methods of distributing discount coupons, and sources of funding in the contingency plan during the pre-implementation period because each assistance program takes time to implement.

- In order to maintain mobility and still save energy, oil taxes should be transferred to the less fuel intensive infrastructure. Oil taxes should also be transferred to health care, education, and other social benefits. Building the infrastructure such as expanding metro train network, building bike lanes and racks, and establishing park and ride lots takes a significant time. Working at home also needs information technology infrastructure. Thus, a plan to cope with a crisis should consider the changes needed to the existing infrastructure in order to make the solution more sustainable. Without other travel options (rather than private cars), high oil prices without subsidies can cause political unrest and economic difficulties. However, with sufficient planning and good infrastructure, panic and concern during oil shortages subside because people are protected from the crisis. This is supported by the optimistic evidence found in the U.K. telephone survey after the 2000 British fuel crisis ended (Noland et al., 2003).

- To successfully phase out fuel subsidies prior to a crisis, public information is needed. Also, the government can use public information to proactively inform the people and industries that, if a crisis occurs, they should not expect fuel subsidies because of the negative consequences. This information should also show how the government is prepared to provide better assistance which will reduce travel costs and which will directly go to targeted groups. This information should improve public acceptance before a crisis by ensuring transparency and increasing trust. Without trust and policy effectiveness, the voluntary measures cannot gain much cooperation, and the prohibitive measures will be opposed by several groups. Moreover, public information helps vulnerable groups recognize and access the assistance offered by the government.

- During a crisis

- Maintaining the market prices for all fuels is hard but very important during a crisis to elevate the effectiveness of the oil saving measures. Fuel subsidies diminish the effectiveness. The assistance program for vulnerable groups helps the country reach the equity goal, but the government also needs to increase mobility via less fuel-intensive modes for everyone. Using several oil saving measures at the same time generates positive synergistic effects, and thus the country can reach the E4 goals.

- The government needs to update its database and makes sure that all vulnerable groups receive appropriate support. The assistance program might need to adjust based on the volume of the shortage, the expected period of the crisis, the cause of the crisis, the condition of the Thai economy at the time of crisis, national and local budgets, and so on. Moreover, policymakers need to monitor fuel poverty, negative effects on different groups of people and different economic sectors. For instance, policymakers might focus more on the tourism industry in the Southern region if the crisis hits during the first quarter as shown in section 4.2 regarding the seasonal effect on gasoline consumption in the region. People from the tourism industry might become a new vulnerable group. Providing thorough and sufficient support to vulnerable groups will reduce resistance to the policy to maintain the market price.

- Policymakers should increase public awareness regarding the necessity to maintain the market price and confirm the connection between oil taxes and fair budget allocation to public transit infrastructure, health care, education, and other social benefits. However, it is important for the government to enact and publicize the existence of such a fair transfer during the pre-implementation period since people will not trust what the government has not yet proved. Another piece of public information which people have often doubted in the past is the oil price structure and the comparison of oil taxes and retail prices between in Thailand and in other countries. Thus, the government should proactively address the fair price structure and fair budget allocation.

- The information must be disseminated that people can receive alternative forms of assistance rather than just compensation for particular groups. Assistance can be the more available travel options, working from home, and so on. The information and travel options should be suitable for the audience and time; for example, disseminating information about free shuttles that connect bus stations and mass rapid transit stations during the hot summer and rainy season in Thailand will increase transit riders' comfort and reduce their costs and time of transit transfers.

4.3.2 Public Transit Enhancement

4.3.2.1 Results from the Online Discussion Forum

There are more than 2,000 threads talking about public transit. Several of them ask how to get to point B from point A by transit while some threads ask how to ride a bus. However, 35 threads are related to public transit enhancement measures and government actions. The comments from the 35 threads are grouped into several issues as follows:

Public transit for children:

- Public transit is neither safe nor convenient for small children. Sidewalks and ways to bus stops are unsafe from parents' perspectives. The public transit network is limited, so travelers need to connect several modes in order to arrive at their destination.

Complaints about public buses and vans:

- Some riders have to travel for long times and distances to commute to work, and have to make several transfers using a variety of modes such as motorcycle taxi or jitney, bus, metro rail, boat, walking, public van, or bicycle. The poor connectivity and numerous transfers make public transit unattractive. In other words, public transit cannot reach people’s doorsteps like a private car can, and staying in congested traffic in a private car with AC is preferred.

- People want to get away from inconveniences such as several transfers, long wait times, long times on the bus/train, poor stations, the lack of door-to-door convenience, crowding, hot weather, and rain and want to buy a car.

- Unsafe driving by bus drivers and poor maintenance discourages people from using public transit.

- Infrequent bus service and no alternative routes are the main complaints; thus, bus riders need more time and have to manage their travel time, which impacts the time they have available before setting out on any journey. Frequently when there are long wait times between buses, the buses become overcrowded. One person’s comment said that he was robbed while he was waiting at a bus stop.

- People complain about smoke from street food, smell from garbage trucks, hot weather, huge crowds, etc. on buses.

- Public transit is not suitable for women wearing high heels and makeup. Rain makes ridership even more inconvenient and congested. Bus stops have no shelters. Walking to bus stops and train stations in the rain is inconvenient.

- When there is an emergency, the emergency door is not used. Passengers are not trained for an emergency while bus drivers and ticketing staff do not direct passengers to respond to an emergency appropriately. Some buses do not have an emergency exit.

- Buses sometimes do not stop at the bus stops. People cannot get off or get on the buses safely. Some buses stop in the middle lane to let their passengers get off or quickly move on without checking whether their passengers completely get off the bus.

- Ticketing staff or bus drivers are rude to passengers. Sometimes they do not nicely inform their passengers who have questions.

- Bus routes are not well planned, and bus and route cancellation without notice is another complaint.

- Less public vans are available when schools start because they are hired by parents to send children to schools.

- Riders want more information, especially about arrival times, bus schedules, etc. so they can plan their trips. When bus companies do not use the available technology, riders do not know when the buses will come and how long they have to wait.

- Calling Complaint Centers does not help or improve anything.

- People complained about too many advertisements and the huge crowds on metro rail and buses. It is hard to see where they are.

Complaints about metro rails:

- Park and ride lots should be sufficiently provided for a free or affordable cost to encourage more people to use transit. Some comments ask where to park the cars in order to ride the metro rail. Some people comment that some park and ride lots are expensive.

- People are not satisfied with the frequent major technical problems which make metro rail stop the service 4 times a month on average despite its high fare. However, some people think that it is better than not having it at all.

- Because of the limited network, the major technical problems that make the metro rail stop the service leads to no alternative route. Moreover, the poor bus service is not a good option. Thus, many people choose to drive.

- Insufficient elevators, no elevators, and poor maintenance at metro rail stations discourage disabled and wheelchair riders.

- Some metro rails have a poor odor and lack sufficient AC.

- People complain about high metro rail fares, especially those who do not buy monthly trip tickets although it is more punctual than buses. The fare does not attract car drivers to switch to public transit and reduce congestion, especially those who travel with more than 2 people.

Complaints about other transportation modes connecting with public transit:

- Some people complain about accidents, unsafe riding, and inconsistent fares by motorcycle taxis which they use to connect to public transit from their homes. Some people complain about expensive taxi fares.

- Walking on undesirable sidewalks which are full of street food and stalls discourages public transit ridership.

- Some people state that walking 10 minutes to/from a bus stop or metro rail stop is too far.

Other issues:

- People from rural areas need cars because of the unavailability of public transit.

- Low-income people are severely affected when oil prices are high.

- Many people have the notion that public transit riders are poor while car users are affluent.

- There are comments on public transit etiquette such as not forming an orderly line, playing on cell phones without holding on to the handrails when standing, and so on.

- People blame the poor public transit on the government, corruption, local mafias that will lose their interest if public transit is developed, poor management and planning, and poor city planning.

- Bus riders want to save travel cost, save energy, and save the world, but they feel that their quality of life becomes poor if they use public transit.

Good things about public transit:

- Transit riders view car driving as a burden. They think that they can see the city, read, or play games at the same time they ride on the bus/train, and do not want to add more cars on the road.

- Some bus riders feel that the service is ok or not too bad, but that it can be improved.

- People expect that the expansion of metro rail networks will improve their quality of life.

- Metro rail might not reduce traffic congestion, but it provides another option for people. Because of its high fare, the metro rail is an option but not for low-income people or a method to make people switch from cars to public transit.

- The automobile industry is very vital for the Thai economy. It will be affected if the public transit system is fully developed and people switch to ride it.

- Generally, public transit is subsidized, but some people feel that it is not fair for taxpayers who live in the areas where public transit is not available. Some comments discuss the fairness of using national tax revenue to subsidize public transit in a particular area.

Suggestions:

- Buses should have improved cleanliness, safety, punctuality, and frequency while metro rail should reduce fares and expand the network, so more people can have access. Inter-province trains should improve technology to utilize high-speed trains and ensure affordability and safety; moreover, this system should accommodate more people during peak seasons.

- More bus lanes with traffic volunteers and police should be added.

- Public transit should have a smart card that passengers can use with any transit system. If a smart card is used, bus drivers have to ensure that all passengers are inside the buses before they move. Currently, passengers have to rush to get on the bus and some pay later since some drivers move their buses very quickly before passengers reach their seats.

- During the political protests to shut down Bangkok in January 2014, public transportation ridership, especially metro rail, increased significantly while car use decreased. This implies that people can switch to public transportation if they have to.

- Some people want the government to impose a fine to the public transit operator for unreliable service.

- Some comments advise working near home, going out very early, renting an apartment near the office, wearing makeup at the office not from home, using fabric refresher to eliminate odor, and buying a condo near train stations.

- Some people would like the government to improve the public transit system because they do not want to rely on taxis.

- To encourage public transit use, the government needs to increase the cost of driving and promote other modes such as biking, and improving sidewalks. The government should give priority to public transit. But some comments indicate that it is hard to increase the cost of driving, especially in the rural areas.

- Good public transit with a large network, affordable price, safe, and good service and operation is needed to mitigate traffic congestion. It attracts more people to ride.

- Some people are happy to work with the companies offering transportation for employees as they can save time and money.

Public transit in regional main cities:

- Chiang Mai will have light rail trains in the future, but some comments mention that based on the plan, the routes and networks are limited. Thus, local people will still use private cars although tourists might take advantage of this.

- Several people feel happy and think that people will have more options to commute in Chiang Mai and other main cities which plan to have light rail trains. Some comments express hope that the plan will be acted upon soon although it is currently planned for the more distant future. Budget and interests of particular groups are the reasons why the project is delayed.

- Some comments mention that the plan to build light rail trains in the regional main cities should consider connecting with other travel modes to allow commutes to other minor cities in the region. For example, there should be a way to get to Lampang from the Chiang Mai airport. The train should run frequently as well.

- Some people do not think that they need the light rail train, but that Chiang Mai should have more buses which cover all suburban areas where most people live. Currently, people must rely on the private red taxi which is available only in the inner city.

4.3.2.2 Information from Articles

Special service for students

Sending children to school generates more trips and congestion. The government and schools should create special services such as school buses/vans for students (Chuanchuen, 1996) because of parents' concerns about their children's safety on public transit.

Complaints about public transit

Several survey respondents complain about lack of proper and safe bus stops and shelters (Chuanchuen, 1996), infrequent service, long wait times, poor condition of vehicles, low coverage of service areas (Bangkok Department of City Planning, 2012b; Srisinlapanan, 2006), and lack of driving etiquette by bus drivers (Srisinlapanan, 2006). Even though a Bangkok survey reveals that car drivers spend more than 2 hours per day commuting, they chose driving over the metro rail because of convenience, greater flexibility, limitations of the network and routes, and a lack of sufficient park and ride lots. Additionally, the metro rail takes longer than driving (Kheawsanun, 2004). Bangkok Department of City Planning indicates that in 1992 there were 4.1 million bus riders per day while the ridership reduces to 1.0 million riders per day in 2011 because of an increase in private car and motorcycles. At the save time air conditioned bus ridership increased from 6% of total bus ridership in 1992 to 52% of total bus ridership in 2011 (Bangkok Department of City Planning, 2012b), suggesting that increased comfort has a profound impact on those who do use public transit.

A need for government to improve public transit

As the comments found on the online discussion forum indicate, people want the government to step in and seriously improve public transportation, and if the country has good public transportation, those who have cars are likely to switch to transit because of cost and time savings (Chuanchuen, 1996; Srisinlapanan, 2006). Cars will be used occasionally only. People also want the government to subsidize public transit costs (Srisinlapanan, 2006). The use of public transportation for trips between provinces was reduced during the 2000s because more people owned cars (Poorat, 2005) while the trips between Bangkok and the provinces increased because the frequency of services increased (Poorat, 2005). If the service is improved and can accommodate people's needs, more people will ride public transit. A survey in the regional main cities shows that people would like to have metro rails available (Chuanchuen, 1996). Public bus operators itself also need more involvement from the government. They complain about insufficient financial support from the government, unclear planning and objective setting, traffic congestion, high fuel prices, and loss of revenue owing to more private car use (Kemapetch & Kidbunjong, 2014).

Characteristics of public bus/van riders

Based on the online discussion forum, people generally view bus riders as belonging to the low-income group. A survey supports this idea, finding that most of the public bus riders in Bangkok who take public bus frequently belong to the low-income group, hold less than a college degree, do not own cars, are female, and are single or divorced while most of the public van riders own cars (Panklang, 2005). Public bus riders in Bangkok are satisfied with the fares but would like to have more buses with AC (Panklang, 2005). Public van riders are satisfied with travel time and convenience but indicate that the fares are quite high (Kraingoo, 2010). These people are frequent riders (Kraingoo, 2010).

Other suggestions

Public transit should employ information technology to improve service (Srisinlapanan, 2006). To enhance public transportation usage, people agree that road pricing in specific areas, driving restriction during particular hours, and increasing parking fee can discourage private car driving (Kheawsanun, 2004).

4.3.2.3 Public Transit Enhancement for Thailand

Discussion of the information found in sections 4.1-4.3:

- Public transit ridership in Bangkok went from 4.1 million riders per day in 1992 to 1.0 million riders per day in 2011 because of an increase in private car and motorcycles (Bangkok Department of City Planning, 2012b). This information is consistent with the findings from section 4.2 for Bangkok showing that a reduction in public transit riders per day associated with a rise in gasoline sale. Moreover, there was an increase in vehicle stock and new vehicles associated with an increase in gasoline sale. Another reason addressed in section 4.1 is that public transit is “an inferior good” (Holmgren, 2007, p. 1031).

- The advantages of public transit riding found in section 4.1 including lower cost, relaxation, no need to concentrate on driving, opportunity to do something else, less pollution, and the opportunity to make conversation with others on the bus (Lyons &

Chatterjee, 2002; Beirao & Cabral, 2007) are similar to the advantages that Thai people mention in section 4.3. Also, some comments in section 4.3 indicate that the quality of life will be better if the transit increases the network and improves service.

- Disadvantages of public transportation found in section 4.1 such as crowding, lack of comfort, “lack of control, unreliability, long waiting times, need for transfers, traffic, lack of flexibility, long walking times” (Beirao & Cabral, 2007, p. 482), unavailability of easy-to-understand information (Beirao & Cabral, 2007; Grischkat et al., 2014), safety (Van Malderen et al., 2012) and the need to carry heavy items (Lyons & Chatterjee, 2002) are not different from the concerns in Thailand based on the evidence in section 4.3 from both the online discussion forum and articles.

- One thing that not found in section 4.1 but found in section 4.3 is the driving etiquette of bus drivers and riding etiquette of passengers. Lack of etiquette probably makes Thailand unique and needs serious improvement. Limited networks, hot weather which makes people prefer riding buses with AC, and perception of riders as low-income are addressed. Crime on the streets and at bus stops, the poor quality of sidewalks, unreliable but expensive taxis, unsafe motorcycle taxis, narrowed streets that public transit cannot access (because of poor city planning especially in Bangkok), and other concerns which indirectly involve public transit ridership are also mentioned frequently compared with the evidence indicated in section 4.1.

- An increase in public transit fares discourages public transit ridership. Experiences and studies shown in section 4.1 also mention a negative correlation (Holmgren, 2007). For Thailand, although some comments on the online forum address the high cost of metro rail fares and the need some subsidization, some people say that the metro rail is already crowded at this price. In contrast, most people find that bus fares in Thailand are inexpensive. Section 4.2 finds the mixed and insignificant results of the correlation in several regions between fares and gasoline consumption. Only the Northeastern region finds a significant positive correlation between fares and gasoline consumption which implies that higher public transit fares discourages people from riding transit but encourages people to drive as in the studies mentioned in section 4.1. However, section 4.2 implies that in Bangkok an increase in transit fares with better quality like the more expensive metro rail can make people satisfied although there is a decline in public transit ridership in Bangkok.

- The online discussion forum and the articles in section 4.3 do not mention how the government responds to a crisis by enhancing public transit use, but it was found that during the protest to shut down Bangkok in January 2014, public transportation ridership, especially the metro rail increased. This implies that people can switch to public transportation if they have to. The evidence from Thailand is consistent with a survey of the 2000 British fuel shortage that found an increase in public transit ridership (Noland et al., 2003).

- Section 4.1 mention that during a crisis there are many first-time riders, so information distribution and channels are very important (Davis, 1983) in order to reduce difficulties. On the online discussion forum, several people asked how to get to point A from point B and how to ride and pay. The answers to such questions should be dealt with by clear transit maps and instructions at transit hubs and stops, not on a forum. This implies that public information from the operators and related units is not sufficient even during a normal situation.

- Section 4.1 provides information on the challenging points of enhancing public transit use, especially regarding limitations of increasing capacity because the transit operators are usually “near capacity, especially during peak hours” (Davis, 1983, p. 92; Cox, 1983a). There are also several barriers (Barker, 1983, Scheuftan, 1983, Davis, 1983). Even during normal circumstances, Thai people consistently complain about poor bus maintenance and unreliability.

- Experiences from section 4.1 mention adding private vehicles and school buses to the system, but the problems with franchises, insurances, and labor contracts occur if they are not considered and prepared in advance (Anderson, 1983; Barker, 1983). For Thailand based on section 4.3, school buses are hardly available, yet people on the online forum request that schools as well as the government step in to create a better system that will reduce the number of trips made by parents during normal circumstances. An article also supports the need for a better system, carefully planned and dedicated to carrying students to and from school because of parents’ concerns about their children’s safety on public transit (Chuanchuen, 1996).

- Although there are several hindrances to enhancing public transit use during a crisis, and some studies point out that public transit enhancement contributes little oil saving (IEA, 2005b; Hartgen & Neveu, 1980; Cox, 1983a), public transit enhancement as a way to cope with an energy crisis gains very high support unlike other saving measures, no matter what the causes of shortages are (Belk et al., 1981). Moreover, based on the discussion in section 4.3, while policies to limit car ownership and usage can reduce congestion and oil consumption, in order for these measures to be successful the areas with these enforcements need sufficient and high-quality public transportation. Meanwhile, other oil saving measures should be implemented simultaneously with public transit enhancement because public transit enhancement contributes a little oil saving (IEA, 2005b; Hartgen & Neveu, 1980; Cox, 1983a).

Recommendations for policymakers:

- Pre-implementation period

- Because public transit is a basic necessity for everyone including low-income people and those who do not have cars, public transit undoubtedly must be a part of the assistance programs mentioned in section 4.3.1.3 of the pricing measures for Thailand. The policymakers should connect the plan for the assistance program with the plan for public transit to accommodate both new and vulnerable groups. For example, if the government issues smart cards for low-income, disabled and elderly people, the public transit operators should make sure that they have a system to accept the smart cards by the time a crisis hits and ensure that they have facilities such as elevators, wheelchair seats to accommodate them; otherwise the vulnerable groups are not able to fully take advantage of the support.

- Poor services and facilities should be improved, and limited transit networks should be expanded before a crisis because it takes time to establish the facilities and there will be more demand for public transit during a crisis. Insufficient and poor public transit reduces its ability to provide mobility at the more affordable price and reduces the effectiveness of an oil saving plan. Moreover, if improvements in public transit are not firmly in place before a crisis, it cannot attract the first-time riders to continue using public transit after the crisis ends as they are likely to have had a bad experience. The public transit policy should be integrated (Santos et al., 2010). Although the Ministry of Transportation takes the primary responsibility for building infrastructure and improving service, other government units should be involved with the plan, and the energy contingency plan, which is the responsibility of the Ministry of Energy, should take the public transit plan and related government units into account.

- Better services with higher fares are acceptable especially in Bangkok.

- Holding emergency preparedness practice and regularly updating the plan to cope with the demands of higher ridership are vital.

- Information technology should be utilized to improve service, so the operators can efficiently manage their buses, trains, and drivers. Technology should provide arrival times, transit tracking maps, smart boards at stations, and transfer information to different buses or different trains for passengers. This will reduce wait time and passengers can manage trips more easily. Using technology helps change people's perceptions of the old poor public transit and can encourage young professionals to be car-independent. The system cannot be changed within a few weeks; hence, pre-implementation is required.

- Because public transit enhancement during a crisis is likely to encounter limitations and barriers which are explained in section 4.1, policymakers need to set up agreements with bus/van rental companies, tourism companies, and related associations to provide vehicles together with trained drivers and insurance. The fares charged by these vehicles might be “higher” because of “more luxurious” vehicles provided, but the new and infrequent passengers might be willing to pay. This strategy reduces the need for subsidies and generate higher comfort for infrequent riders (Cox, 1983b, p. 99-100). Discussion and agreement with the labor unions are also important to have enough personnel working more hours during a crisis.

- Because of the small savings contribution and limitations to having more buses in the system, other saving measures should be implemented at the same time. Eliminating fuel price subsidies and carpooling to main transit stations and non-motorized modes of transport can support public transit measures. Other carpooling routes, telecommuting measures and compressed workweek measures can also reduce crowd on public transit. A substantial pre-implementation period should integrate these measures into the emergency plan.

- Funding is an important issue in increasing the service, and during a crisis, fuel costs become higher. Therefore, oil taxes and other taxes should be transferred to public transit. A transfer system needs to be established, and special funding during a crisis should be ready to be activated when a crisis hits.

- The evidence in 4.3 states that the condition of buses is poor and the Dutch experience written in section 4.1 reveals that the government is blamed for using fuel-intensive public modes (Lee, 1983). Thus, policymakers should ensure that both the regularly used buses in the system and the buses added into the system during a crisis are fuel efficient and are not seen as adding to pollution.

- During a crisis

- During a crisis, there will be many changes such as more frequent schedules, extended service, and new routes; hence, updated information needs to be distributed to frequent riders. First-time or infrequent riders need all basic information in addition to the new information. People might hesitate to ride public transit because of the perception of poor service, so public information with tailored information explained in section 4.1.2.10 are important. Good public information reduces difficulties for the new and potential riders, reduces panic during a crisis as it confirms that people still have options for mobility, and makes public transit more attractive both to new and existing riders. For example, transit operators might provide information about adding night buses for those who have to work night time, information for everyone about the new shelters at bus stops during rainy season, and so on.

- The government should take advantage of technology to improve service and to disseminate information to riders. This helps new and potential riders to switch to the less fuel-intensive modes and sustains the behavior after the crisis ends. Also, technology can be used to disseminate assistance program information such as lists of grocery stores that provide discounts for transit riders, or promoting other assistance or discounts which the public and private sector offer to transit riders.

- Policymakers should monitor the assistance programs regarding public transit and ensure that the targeted groups can take advantage of the support efficiently. Because of crowded conditions, the transit operator needs to pay attention to special groups such as disabled people, senior citizens, children, and people who travel with dependents. In the areas where public transit is not available, policymakers need to ensure that the people can receive other kinds of less fuel intensive assistance.

- The interaction effect or synergistic effect of the several oil saving measures which are implemented at the same time should be monitored. For example, if the government enforces a driving ban, public transit will be more crowded; as a result, transit operation needs to adjust the operating system. Monitoring oil prices and crisis conditions are also important.

- During a crisis, policymakers should use the circumstances to help create a changed image of public transit by using the public information strategy presented in section 4.1.2.10. For example, they can take advantage of the warm glow that people feel when they know they are assisting the country and mitigating environmental damage by taking public transit, rather than driving the private cars. Another example is to create marketing around images of the young professionals, rich, and educated people who suddenly are taking public transit during a crisis to change the image that only poor people take public transit, as well as using images of low to medium income people taking public transit in order to send the message that everyone uses it, as they want to save oil and the environment. However, such a campaign will not create the desired changes on its own; the system and service must also be improved.

- More crowded conditions during a crisis can lead to a bad experience while riding public transit. The government should promote public transit etiquette for all passengers to remind them to respect others. The driving etiquette of bus drivers and friendly and well-trained ticketing staff make riding transit better.

- Thailand has been one of the largest automotive hubs in the world. The concerns over a reduction in domestic automotive sales should be discussed with the stakeholders. The government needs to provide a clear standpoint and make a clear plan. For example, they need to show that the policy does not oppose automobile industry, especially fuel-efficient vehicles. They should also point out that private cars will still be needed for many purposes such as travel with dependents, carpooling, and people making purchases of large items.

4.3.3 Carpooling

4.3.3.1 Results from the Online Discussion Forum

Unlike pricing measures and public transit enhancement, only 153 threads regarding carpooling are found on the online discussion forum. There are 23 threads related to the carpooling measure. The measure is viewed by the forum participants as a policy to reduce the cost of travel, oil consumption, and traffic congestion. The comments are grouped into several issues as follows:

Complaints about carpooling and hindrances:

- Carpoolers (passengers) expect to be offered a free ride by the car owner who is the only driver. The driver is considered stingy and picky if he discontinues the ride or sets new rules that are fair to the driver as well as the passengers. In other words, when the free ride is stopped, or they are asked to share the cost, friends become foes. Some carpoolers never share the cost or give things back to the drivers. Some people think that they do not need to share the cost because the car owners have to pay whether they carpool or not.

- Carpoolers (passengers) are frequently late and do not help clean up.

- Carpoolers eat and talk a lot in the car. Some carpoolers make insulting comments, such as saying that their new cars are better than the old car in which they are carpooling. Other behaviors such as scratching the seat, or closing the door hard are undesirable.

- Those who do not have cars do not look at the incurred cost from the car owner's perspective. For instance, maintenance costs are higher when driving long distances with several people because of the higher weight.

- Some people do not want to carpool because of the lack of privacy.

- Some messages mention that the original poster is too considerate to refuse rides to others. Being considerate is a cultural value of Thai people, who are reluctant to say "No" even when by saying yes an imposition is created. Being considerate also creates problems for people who would rather not share their car with so many passengers or who are reluctant to impose on a friend or colleague who has a car.

- Some people do not support carpooling because the driver has to take all responsibility if there is an accident.

- People do not want to share their car with strangers. If they have a car, they will not carpool. Only close friends or family member are invited because the driver feels comfortable and safe.

- Carpooling and school buses for young children are needed, but they are not popular because of the lack of discipline among parents and students, overprotection by parents, huge differences in school standards which can cause long distance commutes from suburban or rural areas to a good school in a city, distrust and fear of danger and crime, the quality of drivers, the need for children to wear heavy backpacks, etc.

- Carpool campaigns and support were discontinued.

Good things about carpooling:

- Some people find a benefit of in having other people in the car because they do not want to drive alone.

- Some people find nice carpoolers who share costs or give something back to the drivers.

- Carpooling is a way to save oil and money and reduce traffic congestion. Many people support the idea.

Suggestions to stop carpooling:

- Advice from some messages suggest speaking up about problems with the carpooling members, or not carpooling with them anymore. Posting on the online discussion forum does not help.

- People suggest setting rules before they start the carpooling group.

- Advice from several messages suggest rejecting carpool requests from others indirectly such as switching to a motorcycle, going home late, getting a girlfriend, sharing the thread on the original poster's Facebook, inviting friends to apply a direct sale team (so the friends do not want to talk and carpool with), etc.

Suggestion for carpooling:

- Charging or banning solo driving in some zones is interesting, but the government needs to improve public transit service and networks first, provide park and ride lots, and have other alternatives for people.

- Carpooling works for family members, friends, and coworkers, not with strangers. To carpool with strangers, some carpoolers want to carpool with others of the same gender only.

- Companies with a number of employees should provide carpooling vans or buses. Employees can share the cost with employers.

- The idea of the carpool lane is interesting, but with the weak law enforcement in Thailand, people believe that solo drivers will take the carpool lane just as it already happens with BRT or bicycle lanes.

- People do not agree with carpool lanes because, in practice, after they drop off the carpoolers, they cannot take advantage of the carpool lane.

- If carpool or high occupancy vehicle lanes are enforced, there might be professional passengers who fill up other people's cars for a fee. Thus, the carpool lanes would not reduce traffic congestion or oil consumption. Also, the solo drivers will go to unrestricted zones and go a longer distance to get to their destinations.

Regular taxi and ridesharing:

- Regular taxis frequently deny passengers, so ridesharing should be legal, especially during peak hours.

- Ridesharing like Uber is similar to carpooling, but the law does not make a clear distinction between ridesharing and carpooling. The government needs to make it clear, improve regular taxi system, and encourage carpooling.

Using technology for carpooling:

- A thread recommends a website and social network for those who want to carpool. There is only 1 comment, and the person agrees with the idea.

- People ask and suggest about creating an app and other matching systems for carpooling in Thailand. Some people want to create the carpooling community via social media, so they do not have to rely on private cars, the poor public transit, or taxis.

- Some people do not agree that social networking should be used to create the carpooling community because of the potential size, security and safety reasons. They prefer only those who know each other. Some comments suggest collecting identification information or contacting the police in advance during the matching process to ensure safety.

4.3.3.2 Information from Articles

Unlike several opinions and comments found on the online discussion forum, a few articles regarding carpooling are found as listed in section 3.3.3.

Carpooling as a way to reduce cost

Carpooling is viewed as a way to reduce travel costs and save energy (Kusombutt, 2013) as also mentioned on the online discussion forum.

Successful factors for carpooling in an organization

To be successful in implementing carpooling in an organization, commitments from executive levels, the familiarity of employees, economic conditions, social values, and the location of offices are important (Laosirihongthong et al., 2000).

Active carpooling campaign in 1999

The government encouraged people to carpool and encouraged employers to arrange company-based carpooling during the high oil prices in 1999. The government also set up a carpool center. The government pointed out several potential groups such as family members, neighbors, children going to the same school, colleagues at the same and nearby offices, employers and schools arranging vanpools for their employees and students, and shipping companies (National Energy Policy Office, 1999) to carpool. The government believed that its campaign made more people know about carpooling, but putting the measures into practice was difficult because of issues concerning privacy, convenience, and distrust of strangers (National Energy Policy Office, 1999).

4.3.3.3 Carpooling for Thailand

Discussion of the information found in sections 4.1-4.3:

- Although some people in the online discussion forum mentioned good things about carpooling such as cost reduction and having someone to travel with, several of them mention drawbacks in detail based on their experiences. However, the drawbacks do not differ from the evidence shown in section 4.1 such as “high crime rates and the threat of hijacking” (Wakeford, 2013, p. 42) in some areas, privacy and aversion to socialize with others (Zolnik, 2015), and additional distance and travel time to pick additional carpoolers (Jacobson & King, 2009). Fampooling and organized carpooling, which do not have some of the drawbacks, have great potential and should be encouraged.

- "Being considerate", a Thai cultural value mentioned on the online forum, makes drivers hesitate to speak up and set rules for other carpoolers. This leads to bad carpooling experiences. Even when they want to stop carpooling, some people suggest speaking indirectly, instead of talking directly about what they do not like. The same quality of being considerate also makes passengers hesitate to suggest carpooling because they do not want to bother the drivers. This cultural value is not addressed in other countries' experiences in section 4.1. Setting fair rules for carpooling needs to be established as an acceptable social norm to prevent carpooler passengers and drivers from taking advantage or creating problems for each other.

- Some studies in Section 4.1 remind policymakers to prepare for the side effects of a carpooling policy. Carpools often draw the people from public transit during normal circumstances (Wang, 2011; IEA, 2005b) but more from solo drivers during an emergency (IEA, 2005b). Carpooling can mitigate overcrowded conditions in public transit. However, unregistered taxis can use the excuse of voluntary carpooling to avoid licensing. This can affect legal taxi operators and create safety issues (Wang, 2011) as occurred in China. This issue applies to Thailand since ridesharing services like Uber play a more important role in the taxi market, and consumers are not satisfied with the regular taxis as mentioned in section 4.3.

- Unlike the U.S.'s experience, most Thai schools and the government do not provide school buses. People think that driving children to schools creates more trips. The comments on the online discussion forum and the articles suggest that the government and schools should arrange for school buses or vanpools for the students.

- Both evidence from Thailand in section 4.3 and from other countries in section 4.1 mention utilizing information technology for the matching process. However, several comments on the online discussion forum strongly oppose the idea because of issues regarding crime, lack of trust, and not wanting to travel with strangers. This implies that ridesharing with strangers or with matches made via online applications will not work widely in Thailand whereas acquaintance-based ridesharing or fampooling and organization-based carpooling have an opportunity to develop. A study in Thailand indicates that involvement from the executive level (Laosirihongthong et al., 2000) like a study stated in section 4.1 (Su & Zhou, 2012), the familiarity of employees, economic conditions, social values, and the location of work sites are the main success factors (Laosirihongthong et al., 2000) for the organization-based carpooling.

- Cost saving is the main reason to carpool (Teal, 1987; Delhomme & Gheorghiu, 2016; Wang, 2011; Zolnik, 2015) from the viewpoint of people in Thailand and other nations. Participants in the Thai online forum do not mention environmental benefits as a reason to carpool, unlike the experience of other countries discussed in section 4.1 where environmental benefits are mentioned.

- Some studies in section 4.1 mention HOV lanes as a method to enhance carpooling, but the online forum participants indicate that with the weak law enforcement in Thailand, solo drivers will just simply take the carpool lane as already happens with BRT or bicycle lanes. Moreover, they feel there will be professional passengers who fill up other people's cars for a fee.

- Although carpooling is likely to be limited to acquaintance-based and organization-based types, carpooling is very important, especially in the areas where public transit is not sufficiently available (Hartgen et al., 1983; Dare, 1983) like rural areas, or during rail or bus strikes (Brunso, 1983a). Based on comments from the online forum, measures to encourage carpooling also should be applied to Thailand because people living in rural areas generally need car transports because of the unavailability of public transit.

Recommendations for policymakers:

- Pre-implementation period

- The government should create systems that will minimize the risks of providing private information and other problems and should then use the internet-based technology to match riders and drivers before a crisis starts. Internet rideshare matching should not be used only during a crisis, but it should also be used during normal circumstances. The delay of implementing carpooling measures will be eliminated if the technology is continuously used on a regular basis as mentioned in section 4.1.

- Policymakers should prepare the sources of funding such as oil taxes, general taxes, and private funding (such as employers providing or paying for ridesharing as a benefit for their own employees and retailers joining discount programs for carpoolers) (IEA, 2005b).

- The government should arrange for agreements and cooperation among the Internet-based matching agencies, car/van/bus rental companies, tourism companies, etc. together with employers to provide carpooling programs for employees. To encourage the private sector to join the program, policymakers need to prepare incentives for those who contribute such as tax-exemptions, tax credits, and advertising opportunities. Working with schools to encourage the formation of school bus programs or vanpooling is also another strategy.

- Policymakers should perform preparedness practices with the private sector to test the matching technology, set routes, and generate a sign-up program.

- The government should have an established plan to provide public information regarding the carpooling program to those who do not have transit access, those who live in rural areas, those who have dependents or big families, and those who live in the areas with overcrowded transit, so the early sign-up program and carpooling measures can be more effective.

- During a crisis

- If the public transit system has not yet been improved by the time a crisis hits or in the case of a disruption in public transportation, carpooling becomes one of the main travel options for all areas, not only in rural areas. Tailor-made policy designs and public information strategies need to consider the condition of the public transit system in each area.

- Using public information strategies stated in section 4.1.2.10 and using tailored information based on urban setting, income, etc., to provide information about costs of driving alone and information about the available carpooling programs and routes are vital. For example, practical information about cost savings should be more focused on low-income and middle-income people while advertising emphasizing the warm glow and providing praise should be more focused on high-income people. Suggesting fampooling and assisting with traveling plans are more appropriate for people with big families while information about organization-based carpooling and public transit is more appropriate for small family or singles.

- The government needs to update information such as the signup program as there will be more people wanting to carpool and more private sectors joining the program. The government needs to screen and monitor private agencies participating in the programs, and maintain good cooperation between public and private sectors. The screening and monitoring actions by the government will help reduce concerns over crime and the safety of carpoolers, increase carpooling standards with fair rules and carpooling etiquette, and reduce the chance of being scammed by illegal ridesharing. Such government oversight will also help prevent stealing private information by substandard carpooling agencies. This issue might be a new problem for carpooling with the use of advanced technology, so the government should proactively prevent it.

- Fampooling and organization-based carpooling will be more popular (National Energy Policy Office, 1999) in Thailand based on Thai people's comments on the online discussion forum and the government document in 1999. Casual ridesharing might be unpopular, but the government should recommend that carpoolers screen and choose carpooling members by themselves and set basic fair rules to be utilized within the groups.

- Monitoring will allow the government to deal with side effects such as illegal taxis, switching from transit ridership and non-motorized modes to carpooling, illegally using private information, and so on. The synergistic interaction among the saving measures should be considered too. Compressed workweeks might make carpooling arrangements harder, so it might be an option for the employers that cannot arrange carpools for their employees and for employers whose employees can rely on public transit. A carpooling program becomes essential if the government implements oil rationing or driving bans.

4.3.4 Telecommuting

4.3.4.1 Results from the Online Discussion Forum

There are 155 threads talking about work from home, but only 13 threads are related to the telecommuting measures. The comments are grouped into several issues as follows:

Advantages of working from home:

- Some threads and comments show interest in work-at-home jobs. They mention several benefits such as having the opportunity to stay close to family and take care of dependents at home, making life more flexible, having the chance to work for people who have chronic health problems, having greater opportunities for creativity and concentration, reducing stress from traffic congestion and problems with coworkers, saving the cost of commuting and socializing with coworkers, reducing traffic congestion, saving energy, and mitigating pollution.

- Employers can reduce their cost of renting offices and utilities because some of their employees work at home.

- If employees do not need to commute to an office every day, cities and development will redistribute to other places.

- Working at home allows more people to work more than 1 job if they want to make more money.

Disadvantages of working from home:

- Sometimes working at home is not secure. Some people say that they do not receive salary on time. Some HR staff and co-workers view working at home as a way to take advantage of others who work at the office. Some of the people who work at home are assigned to do the tasks that no one at the office wants to do. They often do not get updates from their coworkers. A comment mentions that working at home is a thankless job as no one really sees that he is working.

- People believe that their employers will not allow working from home. Some tasks and positions need employees to be at the office or the site physically. Furthermore, while those in executive positions can work at home, employees with lower positions might have problems because their relationship with their boss becomes weak.

- They will feel lonely if they stay at home. They want to socialize and interact with others. Some people state that they do not have a chance to meet people, and this makes them feel uncomfortable when they do meet people. Some people develop major depression. Working at the office allows people to meet with others, and their networking will benefit their career path.

- Some people plan to go to work in a café or co-working space because staying at home every day is too boring.

- Some people can work at home but do not want to do so because they feel that they have to pay higher utility bills. Moreover, work at home might require a system which involves the cost of the related infrastructure and equipment.

- Some employers might not trust the employee's IT system and have questions about security issues if their employees access the system outside of their offices.

- In the offices that allow their employees to work at home, most employees choose to work at the office because there are better facilities and better expectations from coworkers with whom they need to work with.

- Some people do not want to work from home as they want to separate their work life from their family life. They may want the office atmosphere to energize themselves. Some people say that when they work from home, they work harder and longer than when they work at the office or sometimes need to standby at night. Another disadvantage is that family members may feel the person working from home is not doing much and ask them to run errands for them.

- It is hard to ensure that all employees who work at home do their job productively. Some people mention that Thai people do not have discipline and they do not focus 100% on their work.

- Instead of blaming poor productivity on a lack of discipline or focus, some people blamed employers who do not trust their employees and love to find fault. Part of the culture of Thai organizations is the expectation that employees will be at the office even though there is no work.

Potentials of work from home:

- Work from home and other strategies to work during an emergency were successfully practiced by several companies and government units during the 2011 flood and the 2014 “shut down Bangkok” protest. Additionally, when there is a problem of office safety, some companies successfully allow their employees to work at home.

- Jobs that can be worked from home often require contact with other offices or customers in foreign countries, which can require working at very early or very late times of day. Some companies will allow employees to work at home for 1 to 3 days a week or once a month, although not 5 days a week. This allows the employee to conduct business at times of day when being in an office would be difficult.

- Sales jobs and IT jobs are suited to and are likely to allow people to work from home.

- Current technology better supports work from home and reduces the need to work at the office.

- In the future, work at home will be more tangible because of new trends in business and the different characteristics of generations Y and Z.

- Key performance indicators (KPI) for those who work at home can be changed to rely solely on productivity and output, not availability time.

- In order to keep employees from becoming bored by working at home every day, companies should offer the option of working from home fewer days per week.

- One person's comment says that he wants to sleep at the office, not work at home, so he can save the time and cost of the commute to work.

4.3.4.2 Information from Articles

While a number of threads and comments are found on the online discussion forum, articles studying telecommuting or work from home are scarce. Thus, this section relies on the government's information technology and communications statistics to investigate the potential of telecommuting via information technology development.

Increases in computer, internet, and cell phone uses

While Thailand has experienced increases in computer, internet, and cell phone use, the increase is more significant for internet and cell phones. Table 4.39 indicates the increase in people in Thailand using the computer, the internet and cell phone between 2011 and 2015. However, the growth of the internet and cell phone use in each region are more significant than that of the computer. Bangkok has a higher percentage of the population using the computer, the internet and cell phones than other regions. This implies that Bangkok has better potential for telecommuting. Focusing on the computer, which is more likely than the cell phone to be used for work, the number of people using computers is limited especially in the regions outside of Bangkok, where there are only 30-35% of the total population using the computer (National Statistical Office, 2015a).

Table 4.39 Percentage of Population (Older Than 6 Years Old)

Using Computer (Including Laptop), Internet and Cell Phone in 2011 and 2015

Region	Computer (%)		Internet (%)		Cell Phone (%)	
	2011	2015	2011	2015	2011	2015
Thailand	32.0	34.9	23.7	39.3	66.4	79.3
Southern	30.0	32.8	21.0	37.2	62.6	74.0
Northern	30.6	31.4	23.1	33.5	66.1	76.5
Central	32.2	34.9	23.1	43.1	70.8	83.2
Northeastern	28.4	30.1	20.3	30.2	61.0	74.4
Bangkok	48.2	52.3	40.6	60.6	79.6	90.3

Source: National Statistical Office, 2015a

The younger generation has greater use of computers and the internet

As mentioned in section 4.3.4.1, Table 4.40 shows that the younger generation tends to get used to new technology and be able to use it. Thus, telecommuting should be more feasible in the future. However, about 89% and 87% of people use the internet for social network and entertainment, respectively while about 45% use the internet for receiving and sending emails (National Statistical Office, 2015a). It can simply imply that entertainment is a non-work purpose, and receiving and sending emails is a work purpose, but the statistics do not categorize how much people use social media for work and non-work purposes.

Table 4.40 Percentage of Population Using Computer and Internet by Ages in 2015

User by Age (years old)	Computer (%)	Internet (%)
6-14	80.5	58.0
15-24	63.2	76.8
25-34	41.9	60.1
35-49	24.8	31.8
50 and up	8.5	9.6

Source: National Statistical Office, 2015a

Household increase in computer ownership between 2011 and 2015

Table 4.39 presents the percentage of the population using computers, while Table 4.41 presents the number of computers owned by a household. It is found that Thai household ownership of landline phones and facsimiles decreased, while computer ownership increased between 2011 and 2015. The number of computers owned by households doubled during the period, and in Bangkok every household owns 1 computer on average. These data are a good sign for work from home options in Bangkok although there are several factors other than computer ownership involved with the opportunity to work from home. The Northeastern region has less potential for its population to work from home regarding the infrastructure. 52.2% of Thai households have an internet connection which can be accessed via cell phone and computer. The percentages of the households in Southern region, Northern region, Central region, Northeastern region, and Bangkok having an internet connection are 52.1%, 40.3%, 58.7%, 41.1%, and 77.6%, respectively (National Statistical Office, 2015a).

Table 4.41 The Amount of Information Technology Equipment

Per 100 Households in 2011 and 2015 by Regions

Region	Landline Phone		Facsimile		Computer and Smart Phone	
	2011	2015	2011	2015	2011	2015
Thailand	18.6	12.8	1.6	1.5	24.7	52.3
Southern	17.1	10.4	1.2	0.9	19.8	43.6
Northern	17.8	7.8	1.1	1.0	25.5	47.6
Central	21.7	13.8	1.8	1.6	27.1	52.0
Northeastern	9.3	4.3	0.8	0.5	18.1	36.1
Bangkok	48.3	38.2	5.6	4.9	46.3	103.7

National Statistical Office, 2015a

4.3.4.3 Telecommuting for Thailand

Discussion of the information found in sections 4.1-4.3:

- Working from home might negate the fuel saving and environmental benefits in the long term (Choo & Mokhtarian, 2007) because people might relocate to live further from their workplace, and they might generate more non-work trip from home during the day (Rhee, 2008; IEA, 2005b).

- Both perspectives from employees in other countries mentioned in section 4.1 and from Thai employees on the online forum in section 4.3 are consistent. The benefits of telecommuting are the ability to work and look after their family simultaneously and elevate the opportunity for independent time management (Yap & Tng, 1990), "more flexibility in the workplace" (Dutcher, 2012, p. 362), and so on. Barriers include "isolation while working at home" (Hamsa et al., 2016, p. 417), work-life balance (Rhee, 2008), fragmented communication between telecommuters and on-site employees, the unsuitability of some tasks, role conflicts (mom vs. worker), and questions of fairness to all employees (Yap & Tng, 1990). These issues are stated on the online forum. Some people think that working at home for a few days a week is a good choice. However, based on the online forum, Thai people distrust work from home in general in part because they believe Thai people do not have discipline.

- The concerns from employers' side based on the studies in section 4.1 and the findings on the online discussion forum are not different. Although employers can reduce their office costs, there are several concerns. However, one barrier which is said to be a uniquely Thai characteristic is the perceived need to have all workers at the office even though there is no task to do. This issue is also mentioned in section 4.1.

- The studies mentioned in section 4.1 and the evidence from the online forum and the articles in section 4.3 agree that the potential for telecommuting in the future is likely to be higher because of the availability of more advanced technology. The information from Thailand's National Statistical Office indicates that more Thai people are using the internet, cell phone, and computer. More households have computers and smartphones (National Statistical Office, 2015a). Bangkok is the readiest region for telecommuting based on technology and infrastructure. This is consistent with a study in section 4.1 that finds that telecommuting is expected to gain contributions from urban workers (IEA, 2005b).

Recommendations for policymakers:

- Pre-implementation period

- Because telecommuting needs the involvement of the private sector, investment in infrastructure, and willingness of employers and employees to change, policymakers need to cooperate with the private sector and workers in several aspects. Bangkok should be targeted as infrastructure is available while policymakers should plan to invest more for other regions.

- To implement telecommuting during an emergency, the government needs to have employers, especially large employers, participate in a telecommuting program and ensure the readiness of the necessary infrastructure to work from home such as computers and internet access (IEA, 2005b). Besides the private sector, involvement from related government units is crucial. For example, Thailand's Ministry of Digital Economy and Society should be involved infrastructure issues while the Ministry of Energy and the Ministry of Interior work on the emergency plan. Cooperating with the private sector and preparing infrastructure will take time, so policymakers need to complete these activities during the pre-implementation period.

- To convince employers to invest and cooperate, saving oil during an oil shock should not be the only focus. The benefits of having a telecommuting plan include cost savings for offices, and having a response plan for other events such as influenza outbreaks, terrorist attacks, civil disorders, natural disasters, and so on. Past political protests and the severe flood in Bangkok should remind employers how important it is that they prepare. Providing information about successful practices by other companies in similar businesses and experiences that have maintained or increased productivity will reduce other concerns discussed above and will encourage more organizations to sign up. Information about potential losses incurred if companies do not plan for telecommuting, and other information strategies mentioned in section 4.1.2.10, should be utilized to have more employers take part in the program.

- The emergency plan should identify designated employees, the trigger point for participation (IEA, 2005b), designated positions, the number of days per week to work at home, and so on. Performing preparedness exercises with those organizations on a more detailed level such as who will work from home and how to maintain their productivity and work-life balance is essential.

- The government should adjust regulations to support work at home programs both during an emergency and normal circumstances. Such regulations and support include the minimum infrastructure needed, rights of employers and employees, new incurred costs, etc. to increase productivity and prevent unfair labor practices. Currently, Thailand has the Work from Home Act which aims to regulate the hiring to produce some products in the industrial and manufacturing sector. The Act does not aim to regulate work from home as discussed in this paper.

- During a crisis

- Telecommuting requires little funding by the government and reduces overcrowded conditions in public transit, but it can generate relatively substantial oil savings because of the elimination of travel to and from work if it becomes a large program with active participation from the private sector. Thus, the government needs to update and keep the cooperation with the already-signed-up organizations as well as actively searching for and signing up new participants.

- The government should commend the organizations that actively participate in the program and focus on altruistic behaviors that employers provide for their employees and the society during an emergency. This can increase the non-financial benefits to these organizations and attract more organizations to participate actively.

- Because telecommuting might be limited to urban areas and only some tasks and positions, other oil saving policies should be implemented at the same time, especially in rural areas where advanced technology is unavailable, and for workers in positions that cannot work from home. Several travel options available for everyone will reduce equity issues.

- The government should monitor the side effects such as burdens pushed to employees, work-life balance, non-work trip increase, electricity bills at home, feedback from employees and employers, and so on. The government, involving related Ministries, needs to minimize the adverse effects. For example, the Ministry of Public Health should proactively provide work-life balance techniques and loneliness consultations. The Ministry of Energy should suggest tips to save electricity at home.

- Policymakers need to take greater advantage of telecommuting if a driving ban or oil rationing is implemented and public transit has not yet improved.

4.3.5 Compressed Workweeks

4.3.5.1 Results from the Online Discussion Forum

More than 2,000 threads are found, but only 9 threads are related to compressed workweek measures. The comments from those threads are grouped as follows:

Extended workdays for government employees:

- Some forum participants address that if government officials work 4 days a week with extended hours, people can contact the government units in the evening. However, some participants do not agree with the idea, especially in Bangkok where traffic is too jammed and they cannot go to the government units by 6 pm, the extended hours. Having the offices open until 8 pm will be useful.

- Some people question about efficiency of government officials if they have to work longer hours, as some of them do not work productively even during normal hours.

Challenging points for the extended workdays

- Some people believe that an extended workday will not fit with those who have to pick up family members from school or other offices with normal work hours. They would still have to drive 5 days for other family members.

- Some comments mention the concern that those who already work longer hours will not be able to work 4 days a week. Moreover, some positions and some tasks are not suited to 4 days a week. They might need 7 days a week.

- Compared with the Japanese, Thai employees work less productively and less efficiently. Extending work hours has the potential of giving employees more opportunities to spend time off-task during the day, so compressing the work week not be a choice for Thailand. Another fear is that productivity might reduce during the extended hours of the 4 workdays.

- Some comments concern the availability of personnel who are off on a particular day of the week. Others cannot contact them or substitute for them.

- Some forum participants question how daily workers would be paid.

Benefits of compressed workweeks:

- Several forum participants agree that they would work 4 days with extended hours if their companies had the option. A thread asks people in the forum to vote; 152 people out of 197 people voted in favor of 4 extended workdays.

- Working 4 days with extended hours would give people more time to do a second job on the other 3 days.

- Working 4 days a week with extended hours would allow employees to contact the offices and customers in other time zones. Furthermore, those who work 4-day compressed workweeks are less likely to take time off because they already have a long weekend.

- Working 4 days, employees can reduce the cost and time of travel.

- Compressed workweeks give employees a longer weekend for free time. Some forum participants mention that a longer weekend makes their lives happier and they can work more productively. It also benefits the tourism industry because people may use the longer weekend for tourist activities.

4.3.5.2 Information from Articles

Not many articles regarding a compressed workweek are found. Several people on the online discussion forum would like to work extended hours in order to have a longer weekend. Although the information from the online discussion forum should not be generalized, an article also finds that the respondents are more satisfied with 10-hour workdays than 8-hour workdays (Girdsuwan, 1980). In contrast, another study finds that employees who have flexible work hours are less satisfied with their job than those who do not have that option (Phoncharern, 2007). However, the 2 groups of employees from the latter study come from different companies and different industries. Thus, the comparison has low validity.

Based on the Labor Protection Act of 2008 (B.E. 2551) and amendments, employees are allowed to work up to 8 hours per day, or employees and employers can decide how many hours per day they work, but they cannot work more than 48 hours per week and more than 9 hours per day. For dangerous jobs, employees can work up to 7 hours per day, and they cannot work more than 42 hours per week (Department of Labor Protection and Welfare, 2017; Job DST, 2017). Thus, 10-hour workdays for 4 days a week (4*10) will violate the current labor laws, but extended workdays with 1 day off every other week (8*9) + (1*8) will not. Moreover, based on the law, employers have to pay overtime of 1.5 times the worker's normal hourly wage for the additional hours worked per day (Department of Labor Protection and Welfare, 2017; Job DST, 2017).

4.3.5.3 Compressed Workweek for Thailand

Discussion of the information found in sections 4.1-4.3:

- Compressed workweeks are favored by employees in Thailand, according to the online discussion forum and the article presented above, because they have a more extended weekend, can save travel time and costs, have the opportunity to work a second job, and so on. These opinions are similar to the evidence found in the studies discussed in section 4.1.

- Although some people on the online forum state that they will work more productively because of having a longer weekend, productivity is one of the major concerns on this measure based on the information in both section 4.1 and section 4.3. However, based on the online forum, some Thai people specifically point to Thai workers' characteristics such as lack of discipline and working less productively in general during regular hours as compared to employees in other countries. This concern is aggrandized for government employees as people think that they do not work productively during the regular 8 hours.

- Similar to the studies presented in section 4.1, the online forum participants show concerns over issues created by compressed workweeks such as key personnel who are absent on a particular day (Hung, 1996), people who normally work more than 8 hours for 5 days a week, complications created for fampooling with one family member changing the work schedule or for those who have other commitments (IEA, 2005b), and so on.

- Unlike the studies presented in section 4.1, the evidence regarding the context of Thailand does not mention the side effects of compressed workweeks such as a need to adjust public transit schedules (Schueftan, 1983), changes of sleep patterns, safety at work (Duchon & Smith, 1993), and so on.

- Some studies found in section 4.1 address a need to adjust some regulations. For Thailand during an emergency, a change in some regulations is required to implement compressed workweek measures. Although taking 1 day off every other week does not violate the Labor Protection Act of 2008 (B.E. 2551), the employers have the higher cost of the overtime payment. Also, if the crisis is severe, taking 1 day off every week will contribute more to fuel saving, but it will violate the Act. Thus, some exception during an emergency should be addressed. Government employees who work 7 hours a week can choose to work 10 hours per day for 4 days without violation, but as mentioned earlier people question their productivity.

Recommendations for policymakers:

- Pre-implementation period

- Like telecommuting, the compressed workweek measure needs huge cooperation from the private sector although it needs little government funding. Thus, before a crisis starts, policymakers should discuss and set a detailed plan with employers. The program should be voluntary and focus on workers who live alone because employees living with family are likely to have other commitments (IEA, 2005b), and are likely to fampool with other family members who might not change work schedules. Incentives and social pressure to do something for employees and society can be used to encourage employers to participate in the program. Policymakers should use the public information strategies discussed in section 4.1.2.10 to draw attention and cooperation from employers and employees.

- The government should set criteria or guidelines for employers and work with them to set up a plan to be ready to use in case of an emergency. The designated person, working days and hours, how to contact the employees during the off-day, etc. should be contained in the plan.

- The government must work with transit operators and traffic police to manage all changes required if compressed workweeks are put into effect. The evidence in section 4.1 found a redistribution of morning peak hours and evening peak hours (Ho & Stewart, 1992). Poor adjustment by transit operators and traffic police reduces the acceptability of this measure.

- The government should prepare to adjust the Labor Protection Act to allow a longer workday during an emergency, and require standards and guidelines to ensure healthy conditions for the workers. The laws should be clear about the incurred costs and overtime payment. Without legal certainty, fewer employers will readily participate in the compressed workweek measure at an early stage. Insufficient care for workers' health will reduce their acceptance of the compressed workweek measure. Thus, a legislative change is needed at the pre-implementation period, and cooperation with the Ministry of Labor and the Ministry of Public Health is vital to increase the effectiveness of the measure.

- During a crisis

- Policymakers should update employers, public transit operators, traffic police, and other related parties to make sure that everything goes smoothly. The government should be the center for those important units to exchange and update information, such as a huge shift of workdays from Monday-Thursday to Tuesday-Friday, an approximate number of employees that select 10 hours per day and select 9 hours per day, and so on.

- The government should provide public information to encourage employers and employees to participate more by employing the strategies from section 4.1.2.10; for example, setting goals to reduce work trip generation and making comparison with other companies, commending the organizations that actively support their employees to participate in the compressed workweeks measure, and focusing on altruistic behavior that employers provide for their employees and society during an emergency.

- Because compressed workweeks can make carpooling more complicated (IEA, 2005b; Hung, 1996), policymakers should make an extra effort to attract organizations that cannot arrange carpooling and focus on the areas and the seasons that non-motorized modes cannot be used widely. This measure becomes more important when driving bans or oil rationing is enforced.

- To reduce negative effects of the measures, the government should work with the private sector and other government units closely and provide special supporting programs such as the Ministry of Public Health to emphasize the importance of short breaks and exercise during the day, human resource companies to maintain productivity during long workday hours, related government units to monitor health and safety conditions, and so on. These special efforts should come as a package of extended workday measures (Duchon & Smith, 1993).

4.3.6 Rationing

4.3.6.1 Results from the Online Discussion Forum

Only 9 threads are found in the online forum, and only 3 threads are related to oil rationing measures. Only a few threads discuss oil rationing because the measure has not been used for several decades, as there has been no physical shortage during the recent crises. Many people mention that they have very blurred memories of what went on during the period. Some people asked whether there was an oil rationing during 1979 crisis while some people said they were not yet born. The data from the online forum are thus not very useful, but at least it can be implied that the measure is far from their knowledge. The comments on oil rationing from the 3 threads are grouped as follows:

People have blurred memories about whether, when, and how oil rationing was implemented:

- Some people mention that there were prohibitive measures to save electricity, but they were not sure that it was enforced for oil. Food was also short during the crisis in the 1970s.

Public transit is important:

- In the 1970s, there were measures to ration electricity. However, at that time, several people did not have accessibility to electricity. For oil, they are not sure if it was rationed in the past, but these days public transit is important if oil rationing is enforced.

4.3.6.2 Information from Articles

The Fuel Allotment Act of 1940 (B.E. 2483) was implemented. By the law, the central committee declares which types of fuels are rationed. The committee examines the quantity of each fuel and determines the rationing amount. The committee can determine fuel trading and permitting criteria. Regional committees have to cooperate with the central committee (Fuel Allotment Act of 1940 (B.E. 2483)). However, the Act is considered outdated for the present day and has been abolished in 2017.

The more updated and actively used law is the Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516) and its amendments. Unlike the Fuel Allotment Act of 1940 (B.E. 2483), the Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516) involves both oil rationing and driving restriction measures. The law is implemented in order to respond to a crisis more quickly, effectively, and cooperatively. To respond to an emergency, the prime minister can implement the measures related to fuel production, sale, transportation, holding, export, and import. The law can enforce rules on energy use and activities such as limiting operating times and days for factories, determining hours for entertainment activities, limiting the times, days and conditions for using public and private vehicles, and determining electricity use in buildings, commercial signs, and other places (Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516)).

In the past, Thailand encountered a real physical shortage during World War II, and thus the Fuel Allotment Act of 1940 (B.E. 2483) mentioned above was implemented. The shortage led to oil rationing mainly for government units and the military

(Wisansuwannakorn, 2006). The 1973 oil crisis led to shortages. The 1979 crisis led to high oil prices and the shortages of diesel and fuel oil because oil traders reduced their imports as they were afraid that the government would not subsidize their losses from price controls. As mentioned in section 4.3.1.2, there were also the problems of black markets and illegally blended petroleum products. Public transit operators needed to save on costs by reducing bus frequency, and some had to stop operating (Wisansuwannakorn, 2006). During the 1979 crisis, the government had to ration oil for public transit boats, limiting them to 40 liters per day, and cargo ships which transported necessary goods were rationed by issuing coupons to buy fuel at particular gas stations (Wisansuwannakorn, 2006).

The oil saving policy was implemented via limiting hours and days that gas stations could be open, strict traffic law enforcement, oil saving in government units, and an oil saving campaign for all people (Wisansuwannakorn, 2006). Limited operation days for gas stations in Bangkok in 1980 was not effective because people in Bangkok drove to other areas on Sundays to refill their fuel. The Sunday closure in all areas implemented later has had a psychological effect as people feel that the crisis is real, and has led to a reduction in electricity consumption by gas stations and lighter traffic on Sundays, but . poor traffic conditions near gas stations on Mondays and Saturdays occurred (Wisansuwannakorn, 2006).

The price shocks during the last 3 decades did not involve physical shortages, and price controls were not used, but price subsidization to manage the prices has occurred. As a result, prohibitive measures like rationing and driving restrictions are unnecessary.

Without a physical shortage and prohibitive measures, the shock dummy found in section 4.2 indicates that Thai people are likely to reduce their gasoline consumption during high oil price periods. This might be because of altruism and the need to save travel costs. However, the effect of the shock is blurred in the Southern region and Bangkok. Moreover, the asymmetric models presented in section 4.2 also confirm that Thai people are likely to save more gasoline during times of increasing prices than during times of decreasing prices without the effects of oil rationing and driving bans. With a shortage, the dummy shock is likely to deviate from the one found in section 4.2 because of hoarding and the restrictions imposed by the prohibitive measures.

4.3.6.3 Rationing for Thailand

Discussion of the information found in sections 4.1-4.3:

- Price and allocation controls were used during crises several decades ago in Thailand and other countries as found in the studies in section 4.3 and 4.1, respectively. Besides supply disruptions, oil shortages occurred because there was no incentive for producers and importers to produce and import more as they had to sell fuels at lower prices. From the past experiences, researchers have identified the negative effects and inefficient allocations of price controls (Brunso, 1983b; Lee, 1983) and encourage adoption of price allocations or the free markets. Similar to the case of Thailand, petroleum price deregulation was begun in 1991.

- Although rationing is unlikely to be utilized, some fuels (especially biofuels and renewables) in Thailand are still subsidized and unexpected incidents such as wars, terrorist attacks, etc. might create a need for rationing. Despite the rationing in the past, little information about confusion and difficulties is found in section 4.3. This might be because not many Thai households during that time had electric appliances and vehicles, and the rationing was implemented only for small groups (Wisansuwannakorn, 2006). However, if the measure is to be implemented these days for any reason, it will be considerably more complicated.

- This study has to rely on information about difficulties and negative effects is found in the experiences from other countries presented in section 4.1. As mentioned in 4.1, purchasing ceiling and/or floor measures and odd-even purchasing measures are implemented in order to manage gasoline purchasing at gasoline stations and to reduce oil consumption, but these measures cause long queues at gas stations, increasing panic, unfairness between small cars and big cars, and so on.

- Coupon rationing as mentioned in section 4.1 can provide better equity, reduce panic buying, and encourage more conservation simultaneously. However, low political support and adverse effects are shortcomings (Daskin et al., 1976). For Thailand, some problems such as black markets, illegally blended petroleum products, and reducing bus frequency were mentioned in the past crises (Wisansuwannakorn, 2006).

Recommendations for policymakers:

- Pre-implementation period

- Since oil-rationing measures are likely to incur higher costs on society than voluntary measures, it is recommended using the measures as a last resort (IEA, 2005b; Lee-Gosselin, 2010). However, if the government needs to implement them, much work must be done in preparation.

- The government needs to prepare and update the databases of registered vehicles and registered drivers. Section 4.1 claims that the latter is better. Because some vehicles use gasohol E85, are electric, or use NGV and LPG, the database of registered vehicles should take the kind of fuel used into account and policymakers need to consider advantages and disadvantages if those vehicles are exempted for the measure. The government should also update the priority driving database regularly.

- Because there is a need for administrative work and a huge involvement from central government, regional government, industry, media, etc., the government needs to set up a preparedness plan that includes designating tasks to staff, how to issue coupons or cards that are hard to duplicate, how to distribute coupons or cards, and how to enforce the regulations at local level. Once the plan is formed, as much practice as possible should take place.

- The regulations and plan to address funding for the incurred costs are required because oil rationing generates high transaction costs at both central and local levels. Because of a massive deficiency of data and information, the laws should also address those responsibilities and determine appropriate penalties for not creating appropriate databases and/or keeping them up to date.

- Because the measure limits mobility, policymakers need to increase mobility via other less fuel intensive measures. The plan should be integrated at the pre-implementation period to ensure that people have more options to travel. Policymakers must take into consideration the fact that different areas might rely on different measures, and people who generally drive are not familiar with the new modes or lifestyles. Public information is required to prepare.

- During a crisis

- Because oil rationing has lower popularity than other measures, the government needs to make sure that people perceive that it is fairly implemented and used at the right time for the right reasons (Belk et al., 1981) and if people perceive that the measure is effective in dealing with a severe crisis. Although there are limited resources in the context of Thailand, evidence from the similar policies found in section 4.3.7 (the next section) shows that Thai people question the fairness and effectiveness of the prohibitive measure. Thus, the government needs to provide the information involved with the severity of the crisis and the necessity of enforcing the measure, along with evidence of the effectiveness and fairness of the measure. Most importantly, a careful plan and rigorously monitored implementation are needed to ensure the effectiveness and fairness.

- To implement oil rationing measures, the government needs to mitigate the problem and increase effectiveness by generating a package of saving measures, which offer several travel options (e.g., transit enhancement and carpooling), and trip reduction (e.g., telecommuting and compressed workweek).

- The government should focus on trust, provide tailored information about other travel modes, and other saving measures based on audience. Setting up call centers, smartphone applications, and other communication channels to offer trip planning and information sharing will assist people to find and take advantage of the fuel-efficient ways of traveling and will reduce difficulties.

- Rumor, confusion, distrust, and other negative outcomes are likely to take place, especially in Thailand where political instability exists as mentioned in the online forum comments in section 4.3.1. Consequently, the government needs to ensure better communication channels among the government units, industry and consumers. Public information strategies presented in section 4.1.2.10 should be used to increase willingness to reduce oil consumption by using the less fuel-intensive modes of transportation.

- Based on section 4.1, transferable coupons are better than non-transferable coupons. To avoid the delay in the decision-making step, a particular percentage of shortage and the expected length of shortage should be identified in order to trigger the measure.

- During a crisis, the government has to monitor fuel prices and the quantity supplied and demanded, and monitor enforcement from the central level to the local level. It should be able to adjust the management in detail and solve the unexpected problems rapidly. Additionally, the online forum information from section 4.3.7 points out the problem of fake license plate if driving restrictions are implemented. It is possible that counterfeit coupons or cards can spread if rationing is implemented, so the government needs to monitor these issues as well.

- Other actions that the government might need to take are to monitor black market coupons and petroleum products, substandard fuels from illegal blending, fuel hoarding, and unfair increases in prices of food and necessary goods.

4.3.7 Driving Restrictions

4.3.7.1 Results from the Online Discussion Forum

By searching on the online forum, 17 out of 120 threads are found to be related to driving restrictions. More information than expected was available from the online discussion forum because it is a method used to mitigate traffic congestion which the Thai government has recently discussed for future implementation, especially in Bangkok. The comments on driving restrictions from the 17 threads are grouped as follows:

Problems that can be found from driving restrictions:

- Driving bans create problems for those who cannot access public transit, those with dependents, and those who are poor and cannot buy another car, which people do to circumvent the restrictions.

- Driving restrictions based on odd/even license plates make people buy more cars when there are no other modes to travel, or when traveling using other modes is not convenient. More parking space is needed, such as on-street parking for new cars which causes more traffic congestion.

- People are likely to use fake license plates and change them every day.

- Some people will drive without caring whether it is an odd or even number day. They wonder what government can do to stop them.

- Odd/even license plate restrictions do not work, but odd/even driving based on driver licenses actually limits the number of cars on roads. However, it is hard to check who is violating the laws.

Concerns about equality, fairness, and emergency:

- If a driving ban is enforced, the rules should be equally applied to all, without exceptions for the policymakers, the rulers and the rich. Driving restrictions should apply to taxis as well because there are now too many taxis. Also, taxis should not be allowed to reject passengers as they currently do.

- Driving bans or odd/even number driving days cause a concern regarding emergencies and equality because the rich can have more than one car. Details on emergency cases need to be specified if a driving ban is implemented.

- Driving restrictions are not fair because it limits people's freedom to drive.

- A ban for old private cars in Bangkok to reduce traffic congestion is unfair if old taxis and buses are excluded.

Suggestions and challenging points:

- Some people agree with the odd/even license plate policy in order to reduce traffic congestion. The resistance becomes less if public transportation is good. Driving restrictions are an issue recently because the traffic problems in Bangkok have been in the headline news. The government should improve public transit, make it safer and more convenient, make it available at affordable price, improve connectivity, and so on. There are people who do not want to drive but have no choice because public transportation is poor or lacking.

- Other people disagree and think that the policy does not solve the root cause. Decentralizing development, driving etiquette, law enforcement, etc. are more important than driving restrictions. Some people believe that several policies such as working from home, public transit encouragement, non-motorized modes of transport, etc. should be used at the same time. They think these measures are better than driving restrictions. Furthermore, people say that current cheap oil prices provide no disincentive to driving. If they are expensive, people will keep their cars at home

- Some people agree with road pricing policies in the areas where public transit is well developed only, but do not agree with driving bans.

- If the driving ban is used, the laws need to be strictly and constantly enforced to make it effective. The government needs to ensure that public transit can accommodate the higher demand as people are forced to switch from cars to transit.

- Some people agree with road pricing in Bangkok but want to ensure that the money is used efficiently without corruption.

4.3.7.2 Information from Articles

Articles regarding driving restrictions in Thailand are limited. As the government now tries to cope with traffic congestion in Bangkok with an unclear plan, driving bans such as road pricing in some areas and odd/even license plate numbers are being considered. However, these measures will be used only after several public transit projects are developed (Thailand Daily News, 2016), but the date and details of the plan are not mentioned.

The Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516) and its amendments authorize the government to implement both prohibitive measures. The prime minister can implement the measures related to energy use and activities such as limiting operating times and days for factories, determining hours for entertainment activities, limiting times, days, and conditions for using public and private vehicles, and determining electricity uses in buildings, commercial signs, and other places (the Remedy and Prevention of Fuel Shortage Emergency Decree of 1973 (B.E. 2516)).

- Driving bans like odd/even license plate numbers were not implemented during the 1970s crises, but limiting operating hours and dates of gas stations were imposed. Drivers in Bangkok circumvent Sunday closure by driving to other areas to refill fuels in 1980 (Wisansuwannakorn, 2006).

4.3.7.3 Driving Restrictions for Thailand

Discussion of the information found in sections 4.1-4.3:

- Based on the evidence in section 4.1 and 4.3, people do not oppose the measures if they perceive that the shortage is severe (IEA, 2005b; Olsen, 1983) and if they have no other options (Lee, 1983). However, they are opposed if they think that the measure is unfair and ineffective. For example, if taxis, government vehicles, and elite groups are exempted, people will not support the measure. In addition, the measure tends to affect the poor more than others because the rich can buy several cars. The poor cannot afford to do this and have to take the poor and more crowded public transit.

- There are several similarities between the perspectives from Thai people based on the evidence in section 4.3 and the perspectives from other nations on driving restriction measures. No matter where people live in this world, they tend to find a way to circumvent the measure (Davis, 2008; IEA, 2005b; Wang et al., 2014; Gallego et al., 2013). This behavior leads to less effective energy savings. Going out before restriction times, simply ignoring the driving bans, purchasing another car, borrowing plates from others (Wang et al., 2014; De Grange & Troncoso, 2011), making a fake license plate, etc. are the methods that officials need to deal with. Limiting hours/days when gas stations are open does not effectively help conserve oil because people just change the time and date when they refill gas.

- It is consistent with both sources of information that it is hard for the police to enforce the laws. Violations of driving restrictions take place in the areas with fewer surveillance cameras and police patrols (Wang, et al., 2014; De Grange & Troncoso, 2011) and some restriction methods are difficult to detect. It becomes harder in Thailand where law enforcement is weak.

- Sections 4.1 and 4.3 indicate that in order to implement driving ban measures the governments both in Thailand and other countries need to ensure that other travel alternatives are good and sufficient, and oil prices are high. Like the evidence in section 4.1 shows that the measure becomes more effective if other travel options such as carpooling and public transit are available (IEA, 2005b). People will not drive if they have better options.

- The recently proposed driving ban in Thailand aims to reduce traffic congestion as well as other reasons such as oil saving and pollution mitigation. However, regarding environmental reasons, the side effects of the measure are the greater numbers of new and used vehicles, leading to higher emissions (Davis, 2008). Additionally, the related increase in taxi utilization (Davis, 2008) does not mitigate pollution.

- Some comments in section 4.3 concern emergency issues. Other countries' experiences show that driving because of emergencies must be exempted from the ban. However, the experiences of rationing point out the "difficulties in defining priority" and "delays" for those who are not on the priority list (Anderson, 1983, p. 21).

- Some people on the online discussion forum comment that the measures cannot solve the root cause of the problem. They often mention solutions involving decentralizing development, driving etiquette, and law enforcement.

- Not discussed in section 4.1, Thai people question public administration and suspect corruption, and if road pricing and other restrictions are enforced, they want assurance that the tax revenues are spent properly and efficiently.

Recommendations for policymakers:

- Pre-implementation period

- Because driving restrictions require extensive surveillance, installing surveillance cameras and other facilities in advance helps enforce the measure more effectively. These facilities are not only used for driving restriction, they are also used for speed limit enforcement, accident footage, and so on; hence, this measure alone should not require huge funding for these facilities.

- During a crisis, extra police and other personnel will be needed to patrol this special program, so extra funding is needed. Thus, the plan should address how to access the funds.

- Driving restrictions need cooperation with other government agencies, local units, and related private sectors such as gas stations, employers, public transit, and so on.

Thus, the government needs to prepare and perform preparedness plan practice with these parties. The plan should identify the details such as designated areas, trained personnel, possible ways of violation and how to prevent and monitor them.

- Priorities and exemptions should be identified in the plan. Additionally, the government has to consider whether the exceptions will cover electric vehicles, two-wheelers, gasohol E85 vehicles, NGV and LPG vehicles, taxis, etc.

- Because driving restrictions reduce mobility, the government needs to provide less fuel intensive travel options. Thus, it is important to integrate other oil saving measures and cooperate with related parties. For example, demand for public transit and carpooling will increase, so the government needs to work with public operators and carpooling networks in advance to be able to accommodate the new passengers. Another example is to cooperate with the private sector to facilitate work from home measures. In other words, the preparation for this measure is not only limited to traffic police to enforce the law but it should also increase effectiveness by providing good and sufficient alternatives.

- Public information to facilitate those who are unfamiliar with the new modes will reduce difficulties of the behavioral change. This can lower resistance to adopting the measure.

- During a crisis

- The measure should be implemented as a last resort with a serious shortage because it is likely to generate negative impacts and likely to gain public resistance. In the case of emergency, the measure can be more effective when people are aware of the necessity to save fuels, and it becomes more politically acceptable (IEA, 2005b).

- Based on the information from section 4.3, Thailand has political instability, and Thai people do not fully trust their government and oil companies. Providing information involving the severity and the necessity to enforce the measures with the effectiveness and fairness of the measures can make people understand and increase public acceptance.

- As mentioned above, the government needs to provide other travel modes and options for trip reduction. In addition to cooperating with related parties mentioned above, tailored information for people to choose what is best for them is important to elevate the effectiveness of oil saving and reduce negative impacts of driving restrictions. For example, in rural areas, the focus should be on carpooling and biking information. Furthermore, setting up a call center, smartphone applications, better communication channels to offer trip planning, information sharing, etc. to assist people to find and take advantage of fuel-efficient ways of traveling are very useful. Like other measures, public information strategies provided in section 4.1.2.10 are required.

- Fairness is a problem because the rich tend to have more than one car for a substitution, and in the long term, they tend to buy more vehicles while others keep old cars which pollute more and increase the risk of accidents. Fairness rises if people have less fuel intensive travel options with good quality and affordability. Moreover, the less fuel intensive travel options reduce economic and environmental impacts.

- Specifically for Thailand, the government should make campaigns on transit passenger etiquette and carpool etiquette. Based on the online forum Thai people complain about etiquette often. Making people aware of correct the etiquette in advance can encourage people to switch from cars to other modes.

- The government has to monitor and prevent the methods of violation and circumvention of the measure by covering plates, borrowing plates from others, going out before or after the restricted times, simply ignoring the driving ban measure in the areas with fewer surveillance cameras and police patrols, later purchasing another car, and more taxi riders.

- Generally, driving restrictions have some exceptions such as emergency cases, driving by officers on important duties, etc. However, the designed plan might miss some priorities, so the government should monitor for difficulties and special needs that might need some exception.

4.3.8 Non-Motorized Modes

4.3.8.1 Results from the Online Discussion Forum

Biking and walking are the main non-motorized modes which save energy, reduce pollution, and improve health. There are more than 2,000 threads talking about biking, walking, and sidewalks. Besides those issues, several threads ask where to rent an apartment near offices or within walking distance to bus stops. However, it would be too expensive. There are 32 related threads talking about biking and walking. They were grouped into several issues as follows:

Benefits of biking:

- Some people want to bike in order to save money on fuel and parking fees.

Another reason to bike is to improve health. Biking to work can save time because they can exercise during the commute to and from work.

- Several threads and comments related to biking discuss how to exercise on a bicycle to reach specific objectives such as reducing fat, building muscles, losing weight, and dealing with injuries from exercise. They ask and make suggestions to biking community related to where to bike, how to deal with biking problems, biking tips for travel, how to choose a bicycle, and so on.

Hindrances for biking:

- Projects to encourage bikes might provide bicycles for riders; however, some experiences in Thailand show that this ends up with bicycle loss and broken bicycles if the projects are not well managed.

- It is hard to bring a bicycle on public transit because of crowding during peak hours. Bicycles are not allowed on public transit boats. Public transit should have bike racks to support bike and ride. A good public transit system is necessary to increase biking and walking because people live far from the office and need more than one mode to commute.

- Building safe parking lots for bicycles will encourage biking and reduce traffic congestion.

- People fear for their safety because bikers have to ride on the road with high-speed cars. Biking at nighttime increases concerns. Bikers need to ensure that they know how to maintain their safety on the roads and have sufficient supporting equipment.

- Road condition with cracks and potholes is one of the main problems. Pollution on the road also discourages some people from biking. Other problems include the number of homeless dogs in Thailand and street crime.

- Bicycle lanes should be enforced strictly, otherwise, they become car parking lots as occurs in several places.

- People who bike to work or school need to prepare clothes, shower kits, and so on because of hot weather in Thailand.

- Some drivers have a negative attitude toward bikers who conserve energy and reduce pollution, especially biking for exercise purposes although everyone should equally have the right to use the roads, not only car drivers.

Voices from drivers against biking:

- Some drivers feel that bicycle lanes take cars' parking space and there are reduced or no options for drivers to park.

- Some people disagree with bike lanes in the areas with small roads and public transit because it makes traffic more confusing and congested.

- Some people disagree with biking campaigns which use road space. Biking campaigns sometimes these days do not create any benefits as some people find that participants aim only to show their expensive bicycles and they actually drive to the campaign areas. However, cyclists feel that it is an unfair complaint because drivers use the roads most of the time. Cyclists and pedestrians should have the same right, and they do not pollute like car drivers do.

- Car-free day campaigns heavily focus on biking. They should instead encourage other options such as public transit, walking, and so on.

- Some biking campaigns which need to close some roads focus on exercise. Some online forum participants do not agree with this purpose because bikers should bike and exercise in specific areas or parks, not on the roads. The campaigns should also focus on the bike for commuting in real life, not just for fun.

- Some comments mention that bikers should strictly follow traffic rules and signs as well.

Hindrances for walking:

- Pedestrians say that it is hard to walk on sidewalks because there are so many street food vendors and stalls on the sidewalks in Thailand. Furthermore, many sidewalks are encroached on by shops, restaurants, parked vehicles, utility poles, and so on. Weak and inconsistent law enforcement lets shops and stalls come back on the sidewalks after they have been chased away. Other unattractive components of sidewalks are wires hanging free overhead, dirt, and water. Disabled people and other pedestrians have to walk on the street.

- Some sidewalks are used as streets for motorcycles when traffic is congested or when motorcyclists want to drive against the flow of traffic, so pedestrians feel unsafe.

- Some people blame the disgusting sidewalks on the government, corruption, law enforcement, and carelessness.

- Crossing at crosswalks is not safe because many cars violate pedestrian traffic lights and crosswalks.

- When walking on sidewalks, women sometimes experience sexual harassment. Some people are also worried about street crime.

- Some online forum participants want to walk to the office in order to exercise and save oil, but they are not sure whether other people will think that they are weird.

- Some people say that it is too hot to walk in Thailand. Rain also makes people who ride motorcycles and bicycles or walk have to prepare more because they might get wet. Raincoats, showers at the office, hair dryers, boots, etc. are important.

- Because of hot weather in Thailand, trees should mitigate the problem. However, tree trimming and removal on sidewalks are not professionally done so trees become ugly and useless.

Voices from drivers against walking:

- Some online forum participants are upset with pedestrians who do not cross at crosswalks or pedestrian overpasses.

- Walking and running campaigns are criticized by drivers because they cannot drive on some roads and the campaigns make traffic more congested.

Benefits of walking:

- Some people want to walk or bike to the office to improve their health. Several comments in a thread talk about walking a lot, like the Japanese do, makes them slender and healthy.

4.3.8.2 Information from Articles

Benefits of biking

Biking is a good way to save travel cost, and reduce emissions and global warming (Rachatapiti & Jiamphao, 2015; Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015), and a good way to exercise (Phala & Bejrananda, 2016; Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015). People usually bike for short distances, around 4-6 kilometers to local grocery stores, local markets, and public parks (Phala & Bejrananda, 2016), or within universities (Rachatapiti & Jiamphao, 2015). For the younger children, biking is a means of having fun on the way to school as well (Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015). In some cases, biking is faster than other modes of transportation (Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015).

- *Needs and limitations from bikers' perspective*

Bikers would like to have consistent bike lanes (Rachatapiti & Jiamphao, 2015) (Pulkasiwit & Tason, 2015). Because Thailand is hot and rainy, bikers need a covered bike lane like at a university (Rachatapiti & Jiamphao, 2015). Without the covering, many people do not want to ride in that climate (Phala & Bejrananda, 2016). Some women students would like to bike but their uniform, with a skirt, discourages them from biking (Rachatapiti & Jiamphao, 2015). Lots of cars on the roads during peak hours and high speeds on the roads discourage people from biking as well (Phala & Bejrananda, 2016; Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015). An increase in travel time is another drawback compared with using other vehicles (Phala & Bejrananda, 2016). Homeless dogs, intersections, roundabouts, and crime also make people hesitate to bike (Chaowarat, Sawangchaeng, Piriyakarnnon & Netrapra, 2015).

- Needs and limitations from pedestrians' perspective

Pedestrians think that safety, convenience, no obstructions, nice landscaping, and sufficient lights on sidewalks are important (Kuabpimai, 2013). Pedestrians would like the government to manage and enforce the law on street vending more strictly and want the government to ensure availability of handicapped user-friendly facilities on sidewalks (Kuabpimai, 2013).

- Poor quality of sidewalks

In Bangkok, many sidewalks are narrow, rough, unsafe, and obstructed. The sidewalks have insufficient numbers of trees and shading (Chinorak & Dankittikul, 2015). Land in the areas are developed, but the sidewalks are not. (Chinorak & Dankittikul, 2015). #

- Problems of street vending

Street vending is a problem for pedestrians, but strict law enforcement on these groups of people can cause problems and needs to be carefully considered. Studies show that street vending is related to low-income sellers (Bangkok Department of City Planning, 2012a) with less than 6 years of education (Nirathorn, 2014). The food and other products are mainly purchased by low and medium income buyers (Bangkok Department of City Planning, 2012a). Eliminating street vending or re-organizing it not only involves poverty and jobs, but street vending is also the culture of people in the community (Bangkok Department of City Planning, 2012a; Nirathorn, 2014).

4.3.8.3 Non-Motorized Modes for Thailand

Discussion of the information found in sections 4.1-4.3:

- Good biking and walking facilities are important to encourage people to bike and walk. Safety is the main concern. These facts are mentioned in both section 4.1 and section 4.3. More uniquely for Thailand, the hindrances for non-motorized modes are street food stalls and street vending, street crime, the poor condition of sidewalks, motorcycles riding on sidewalks, and homeless dogs. Another issue is bike lanes which are taken as on-street parking for cars and motorcycles.

- Unlike the evidence presented in section 4.1, several pieces of evidence in section 4.3 say problems are caused by or not corrected because of weak law enforcement, lack of discipline in car drivers (e.g., not stopping at crosswalks), motorcycle riders (e.g., riding motorcycles on sidewalks, not stopping motorcycles at crosswalks), bikers (e.g., not following traffic laws), and pedestrians (e.g., jaywalkers), public administration, city planning in Thailand, and poverty and economic difficulties.

- Non-motorized modes reduce travel costs, mitigate environmental damage, and improve health. These are found in section 4.1 and section 4.3. While several biking campaigns in Thailand aim to encourage people to exercise, car drivers feel that bikers should exercise in other areas, not on the road. Moreover, some campaigns are ineffective because some participants want to show off expensive bikes rather than actually use them as transportation.

- The evidence from other nations suggests that pedestrians, cyclists, and drivers are not treated equally indicating that drivers have more privileges and better conditions

(Mullen et al., 2014). In Thailand, there are some negative feelings between bikers and drivers; for example, drivers complain that road space is taken by bike lanes and that they have to pay more attention to the road if there are more bikers; bicyclists point out that drivers use roads all the time but biking campaigns use roads only a few hours and they feel the complaints about the campaigns lack validity because of this.

- Although safe bicycle routes and sufficient and attractive bicycle parking facilities are the key factors for success, "conformity and peer effect" are the main factors in the Netherlands (Martens, 2007, p. 336). Similarly for Thailand, hesitation to bike and walk to the office and school exists in part because people are not sure what others will think.

- Weather is one of the main issues mentioned in section 4.1 and section 4.3. In Western countries, cold weather, short daylight hours, and rain discourage using non-motorized modes (Hong, 2016). Thai people mention that the hot weather and rain make non-motorized modes harder to use.

- Although non-motorized modes the Netherlands are successful, there are complaints about overcrowded public transportation during peak hours leading to difficulties for bike and ride. "Lack of attention" for biking from particular governmental units and no "involved authority" result in some difficulties (Martens, 2007, p. 336). For Thai bikers, the lack of bike racks on buses and overcrowded conditions on public transit make it hard for them to bike and ride, and some public transit does not allow passengers to bring bikes with them. Renting or borrowing bikes might not work in Thailand because of irresponsibility and theft.

Recommendations for policymakers:

- Pre-implementation period

- Both push and pull measures are important to increase oil conservation and reduce difficulties. The government should provide walking and cycling infrastructures and favorable environments such as cutting crime rate for safer streets and sidewalks, well-maintained sidewalks which are not obstructed by street vendors and others, dedicated biking lanes with strict enforcement, bicycle racks at main bus stations, homeless dog reduction, and strict enforcement of motorcycles riding on sidewalks. Each issue takes considerable time, but policymakers should consider them to elevate the effectiveness of the measure and to maintain non-motorized modes after a crisis ends.

- Policymakers need to ensure the policy is integrated. Cooperation among different units is important, so preparation before the time of crisis will increase the effectiveness of the measure. For example, policymakers can discuss with public transit operators how to achieve a bike-friendly system and discuss with Ministry of Public Health ways to encourage people to exercise.

- Changing the attitudes of drivers, bikers, and pedestrians is important because there are feeling of resistance among the 3 groups based on the discussion on the online forum. Equality in transportation should be created.

- Oil taxes should be used as a source of funding, but other taxes and budgets should be used to promote non-motorized modes as well because the measure provides multiple benefits such as for health, tourism, and the environment.

- During a crisis

- Because most people live far from their workplace, bike and ride program must be strongly promoted. These programs need to cooperate with public transit and the city to provide bike racks on the bus/train and in main bus/train stations.

- Thailand's problems such as homeless dogs, street vending, motorcycles riding on sidewalks, street crime, etc., should be diminished during the pre-implementation period in order to have more people participate in non-motorized modes during a crisis.

- Public information is important to encourage conformity and peer effect to increase the confidence of pedestrians and bikers and attract more people to participate. Policymakers should not only aim to save oil, but they should also help people to connect the primary purpose of saving oil with peripheral benefits provided by the warm glow, praise, healthy workouts, and zero pollution.

- Policymakers should employ social and behavioral theories mentioned in section 4.1.2.10 for tailored information provision; for example, encouraging the rich to switch to non-motorized modes by focusing on the opportunity to exercise while they are commuting.

- The government should start non-motorized modes at the early stage of any crisis, but the effectiveness will depend on the above push and pull measures. Policymakers have to monitor for the concerns and interactions between the pedestrians/bikers and drivers. For example, pedestrians with slow walking speeds, people with wheelchairs, and children might be exposed to severe air pollution produced by drivers; the police should pay more attention to street crime to ensure people's safety or have a walking escort program, especially for women or anyone who travels alone at night.

- Laws should be enforced strictly to encourage equality in transportation such as making sure everyone (pedestrians, bikers, motorcyclists and drivers) stops at crosswalks, getting rid of illegal street vending, arresting riders of motorcycles riding on sidewalks and jaywalkers alike, and so on.

- The government needs to monitor the interaction between other saving policies and the non-motorized modes. For example, carpooling might draw people from walking/biking; good public transit and bike-friendly systems will encourage more people to walk and bike to transit stations. On the other hand, gasohol price subsidies will keep people driving, not switching to the less fuel-intensive modes.

- Policymakers should take seasonality into account because the natural environment influences non-motorized modes more than other measures. For Thailand, non-motorized modes will contribute less if a crisis occurs during the rainy season. Policymakers might cooperate with employers to provide shower rooms or plan to increase the number of big trees for shading and heat reduction during hot summers.

4.3.9 Eco-Driving

4.3.9.1 Results from the Online Discussion Forum

More than 2,000 threads discuss eco-driving, and 36 threads out of them are related to the oil saving measures. The speed limit is the most frequently mentioned on the forum although other eco-driving techniques are mentioned. The comments from the 36 threads are grouped into several issues as follows:

Support for speed limits:

- People discuss the appropriate speed for pick-up trucks and motorcycles because they are generally used in daily life and they want to reduce their cost, but the information is hardly found in the media and the government focuses on sedans.

- Getting tickets by mail because of breaking the speed limit is better than being confronted by the police because some people quarrel with the police. Additionally, having speed cameras makes drivers more careful and comply with the law.

- The speed limit should be strictly enforced because of safety reasons. Additionally, the speed limit is important because many Thai people do not have driving etiquette.

Issues about speed limits:

- Discussions on speed limit often compare Thai speed limits with other countries. People use the rules in other countries to support their arguments for or against speed limit laws.

- 80-90 km/h is recommended for energy saving, but some comments indicate different appropriate speeds for their cars. Several people question whether the level recommended by the government and media is correct for their cars.

- Some forum participants view the idea of 90 km/h as old knowledge that does not interest them. Some people think that 90 km/h is an outdated rule because of the new technology and safety. Some people believe that the speed limit of 90 km/h makes drivers sleepy.

- Some people talk about the annoyance of drivers at 90 km/h in the right lanes. (Thailand is country where people drive on the left-hand side of the road). Driving at 90 km/h takes a significantly longer time.

- Some people state that it is stupid to limit the speed in some areas. Some comments say that the country should not have a speed limit at all.

Law enforcement on speed limit:

- The problems of controlling speed limit are driving etiquette, awareness, and law enforcement. Some people say that if the law is not enforced, the law should be canceled.

- Some people say that because of the weak law enforcement at the driver level, the government should legislate speed locks at 120 km/h from car manufacturers. However, others disagree because the drivers feel that the law should put limits on and enforce what people do, not what the car is capable of.

- Some people doubt whether speed cameras really work. They question whether speed cameras can really get the right speed.

- Some people distrust the government, for example, they feel that fining for the speed limit is the way policemen make money. Some government vehicles and news reporters' vehicles drive over the speed limit too, but people believe that these groups do not get tickets.

Several tips for eco-driving (apart from speed limit):

- People mentioned that turning off AC would save gasoline but opening the window would offset the saving.

- Several people suggest not accelerating or decelerating frequently.

- People discuss whether energy saving tires work and discuss their disadvantages such as their value, safety, and so on.

- People discuss the recommended tire pressure level regarding energy saving, safety, comfort, and maintenance.

- It is suggested that new cars have an eco-mode function and eco-drive navigator, and that owners of old cars install an eco-driving device.

- Some people mention that they attend eco-driving competitions and training with automotive companies to gain some knowledge.

- Because of traffic congestion, numerous intersections, etc., people in the forum discuss how to eco-drive in a city. Besides acceleration and deceleration techniques, people mention planning their trips, choosing the route and time to avoid traffic, taking unimportant stuff out of their cars, avoiding idling the engine, and so on.

Challenging points for eco-driving measure:

- Some people think that eco-driving saves very little while others find that it saves a lot.

- Several methods of oil saving and electricity saving are listed on the threads, but there is no comment or there are few comments. However, the threads that ask people to share their own methods have more active involvement and participation.

- Some threads discuss whether the energy saving information from media is correct as they have received different information from some practitioners. Myths and facts about sustaining a steady speed, cruise control, pulse and glide, etc. are mentioned, but there is no conclusion at the end of the threads.

- Eco-driving navigators are beneficial only for those who care about and who understand how they work. Moreover, some people doubt if the device is credible. Saving energy depends on self-awareness.

- People in the forum discuss how to save oil for a specific car because people find that different cars have different and very detailed oil saving techniques.

- Some people say that they have to idle the engine during traffic because they are afraid that they will not be able to restart the engine. In older cars, restarting the engine often will consume more energy and make the battery deteriorate faster.

Oil saving in general but found in eco-driving threads:

- Some forum participants mention using public transit, carpooling, biking, switching to LPG, and riding motorcycles even though they are not eco-driving techniques which are asked about by thread owners. This is because these travel modes consume less energy or do not consume energy at all.

- Lack of driving etiquette, selfishness, and weak law enforcement are serious problems in Thailand and need to be fixed urgently.

- People blame traffic congestion on inefficient public administration.

- Because of a small number of policemen, some people think that social networks can help improve law enforcement by taking pictures or videos of those who violate the laws. However, some people think that someone might try to accuse others by editing the files or using the old pictures to defame them.

- There should be a unit/department to help people plan their trips with different modes of transportation in order to reduce private car use.

- Cars are used to show people's status. Having cars is not a bad thing, but car owners should be responsible to society and switch to other modes of transportation when it is possible.

- As a part of society, some people want to save energy, reduce traffic congestion, and mitigate pollution, so they use public transit and other ways to save energy. However, they feel depressed when they see lots of people do not do so and their behavior becomes useless.

4.3.9.2 Information from Articles

- *Ways that Thai people choose to save fuels*

Eco-driving is important because it reduces travel costs (Kusombutt, 2013). There are several ways to save fuels, but regular car checks and maintenance are real-life options that people actually utilize (Tongsook, 2011). 90%, 83%, and 79% of interviewees already use regular car check and maintenance, driving at or not over 90 km/h, and trip planning beforehand. Other behavioral changes people select for oil saving include carpooling (65%), public transit (62%), and switching to NGV (29%) (National Statistical Office, 2007). Another survey finds that some of eco-driving techniques are easy, but only 51% of respondents actually take unimportant stuff out of their cars, and only 47% do not idle the engine while they are waiting (Seniwongs, 2015). Another least popular method is only turning on AC when needed (Tongsook, 2011).

- *The government provides public information and creates eco-driving project*

The government provides information about eco-driving tips (Ienergyguru, 2015; Federation of Thai Industries, 2014). Besides public information, the government has projects to follow up and evaluate how much fuel drivers can save after training. In the transportation sector, the drivers can save 0.9%-10.0% of fuel consumption from acceleration and deceleration technique, 1.1%-14.0% from using GPS to track idling, and 0.9%-13% from setting driving efficiency in km/liter (Federation of Thai Industries, 2014).

- *Efficiency of public information*

A survey indicates that people in Bangkok are likely to receive oil saving information via television and friends while information provision via magazines and signs is less common. Respondents also mention that the content and presentation format of oil saving information provided by the government are not interesting and not emotionally charged (Tongsook, 2011). Accessibility to information or distribution channels is a problem because of infrequent and inconsistent campaigns. Public information is broadcasted during inappropriate times (Tongsook, 2011)

- *Eco-driving myths*

A study shows that 88% of car users think that eco-driving is important, but 63% admit that they do not know the right ways to save fuel. 75% believe that idling in order to warm up the engine for a while will save fuel. People’s understanding of how to save fuel at home is better than their understanding of how to save fuel on the road. From people's perspective, oil saving information from engineers and scientists is more credible than other sources (Seniwongs, 2015).

4.3.9.3 Eco-Driving for Thailand

Discussion of the information found in sections 4.1-4.3:

- Based on data in sections 4.3 and 4.1, Thai people and people from other countries hold similar opinions on speed limits. The benefits of speed limits are oil savings and safety, but people discuss the annoyance of slow driving (Alam & McNabola, 2014) and Thai people add that some slow drivers drive in the right lane (they are supposed to drive in the left lane). Increased commute time is another negative impact (IEA, 2005b) mentioned in both samples.

- A speed limit reduction policy requires clarification which the civil society can connect between speed reduction and energy savings (IEA, 2005b). This is also true for Thailand as people on the online forum are not sure if the information they receive from media is correct and updated. They also want more specific information for their particular vehicles such as the recommended speed for a specific car model, speed levels for old and new motorcycles, speed levels for pickup trucks, speed levels when driving in urban areas, and so on. People mention that they find just general information for cars, but they would like to have more information on motorcycles and pick-up trucks which are widely used in Thailand.

- Speed limits require infrastructure like speed limit signs, equipment like speed cameras, and personnel like the police to enforce the measure (IEA, 2005b). Based on the evidence in section 4.3, Thai people agree that these requirements are important, but that weak law enforcement, lack of driving etiquette, distrust in the police and corruption are the problems for their country. Also, some people question if speed cameras can get the accurate speed.

- In addition to speed limits, other eco-driving behaviors. Based on the samples in section 4.3, Thai people also talk about these techniques. However, some people find it helps save oil just a little.

- Eco-driving training, vigorous campaigns of public information, and utilizing technologies providing car users with feedback on how fuels are consumed (IEA, 2005b; Carrico et al., 2009; Barkenbus, 2010) are addressed in the experiences in section 4.1. Thailand's evidence also mentions these options, and an article finds a mild to significant improvement during an experiment, but some people in the online forum say that people who do not care will not pay attention or will not understand the onboard information systems.

- It seems that Thai people know about eco-driving tips but some studies reveal that only 51% of the respondents take unimportant items out of their cars, and only 47% do not idle the engine while they are waiting (Seniwongs, 2015). Another least popular method is only turning on AC when needed (Tongsook, 2011). These examples are the "intention-action gap" (Frederiks et al., 2015, p. 1386) addressed in section 4.1, especially in the public information section which Thai policymakers should not overlook in order to generate an effective campaign.

- Based on social and behavioral theories, section 4.1 points out that using messages with information about "social norms" and information compared with their "personally relevant" social groups will be more effective than the messages that deliver only "energy saving tips" (Frederiks et al., 2015, p. 1390). This fact is consistent with the online forum evidence that participation is not active in the threads providing only oil saving tips whereas it is considerably more active in the threads with the information from their personally relevant social groups.

- The studies in section 4.1 state that eco-driving in some places is considered the exception, but it should be the norm of driving behavior (Barkenbus, 2010; Barla et al., 2017) for a longer-term impact. Based on the data from section 4.3, eco-driving in Thailand is not only the exception, but several other problems such as lack of driving etiquette, selfishness, and weak law enforcement are also serious problems. A sophisticated multidimensional campaign (Barkenbus, 2010, p. 765) are required.

- The information from 4.1 suggests targeting outdated information and myths (Carrico et al., 2009). With the outdated beliefs, 80% of the drivers in the U.S. report that to "save fuels, save money, reduce emissions, and prevent vehicle wear and tear", they idle the vehicles for up to or more than 30 seconds rather than shut off and restart the engine (Carrico et al., 2009, p. 2886). For Thailand, a study shows that 63% of the respondents admit that they do not know the right ways to save fuels, and 75% think that idling in order to warm up the engine for a while will save fuel.

Recommendations for policymakers:

- Pre-implementation period

- The measure involves a lot of information provision. Policymakers need to identify and update eco-driving tips and specific information, and this information should be readily prepared at the pre-implementation period. They should provide both a general information version and more specific versions. A more specific version should provide speed levels for specific car models and ideal speed levels for motorcycles and pickup trucks. The government should utilize advanced technology by developing a user friendly program or application to give the users specific information to fit their needs.

- Policymakers should identify myths and popular beliefs that need to be corrected such as the idling mentioned above, and then emphasize the updated and correct information to the targeted groups.

- Policymakers should cooperate with the private sector, other government units, experts, and the media to prepare to disseminate information effectively via several channels such as televisions (Tongsook, 2011) and information communicated via "interpersonal channels" such as respected friends and neighbors (Costanzo et al., 1986, p. 527; Tongsook, 2011). They should consider setting up a short eco-driving training program to be ready for a higher demand during a crisis.

- The government has to prepare laws and agreements such as speed limits on highway and agreements with auto service centers to check tire pressure for free. Moreover, it needs to ensure how laws will be enforced, for instance, having infrastructure like speed limit signs, equipment like speed cameras, and trained personnel like the police and volunteers.

- Funding should be specified before a crisis starts. Speed cameras should be funded by other budgets instead of oil taxes because of their multiple benefits. Sources of money for the increasing numbers of volunteers and increasing work hours of personnel during a crisis, and information provision and campaigns should be identified. For instance, the automobile industry might sponsor eco-driving competitions and they can promote their business and build sales simultaneously. Car insurance companies might offer a discount for those who are eco-driving trained.

- During a crisis

- The eco-driving measure can maintain mobility at normal levels with more efficient fuel consumption; consequently, it is a good choice for those who cannot ride public transit, join carpools, or work from home. People with dependents, senior citizens, and people with wheelchairs can take advantage of eco-driving, as can people who live and work far from the city centers. The rainy season will also increase the usefulness of the measure, as people prefer riding in cars to avoid getting wet. However, the government should not rely only on this measure.

- Policymakers still have to focus on the outdated information and myths as mentioned in the pre-implementation period. Providing tailored information and techniques for those who drive in urban areas and rural areas or more specific details increases the effectiveness of the measures. Using experts such as engineers and scientists (Seniwongs, 2015) as mentioned in section 4.3.2 and the persons perceived as most "credible and trustworthy" such as practitioners and respected friends as mentioned in 4.3.1 to disseminate the information are useful (Costanzo et al., 1986, p. 527). Besides, televisions rather than magazines and signs (Tongsook, 2011) and "interpersonal channels" such as respected friends and neighbors (Costanzo et al., 1986, p. 527; Tongsook, 2011) are likely to be more effective.

- As mentioned earlier, the eco-driving measure requires a lot of information provision. Information content that is simpler but vivid (Costanzo et al., 1986) can be readily prepared at the pre-implementation period and can attract drivers' attention to change their behavior at an early stage. Based on a study in Thailand, the government has to improve its public information strategy because of the finding that the content and presentation format of oil saving information provided by the government are not interesting and not emotionally charged (Tongsook, 2011). Distribution channels or accessibility to information is a problem as well because of the infrequent and inconsistent campaigns. Additionally, public information is broadcasted during inappropriate times (Tongsook, 2011).

- Policymakers should not overlook the "intention-action gap" (Frederiks et al., 2015, p. 1386) as mentioned in section 4.1.2.10. For example, using messages with "social norms" and the information compared with "personally relevant" social groups rather than messages that deliver only "energy saving tips" (Frederiks et al., 2015, p. 1390).

- The government should sustain eco-driving behavior by making eco-driving the norm for driving. Advanced technologies like a user-friendly program or applications to provide specific information of speed limits for a particular motorcycle model, driving in congested areas by a specific car, etc. can be prepared at the pre-implementation period and should be emphasized.

- The government needs to monitor the side effects that may take place such as increased travel times, pollution from increased travel times, accidents from distractions, the increase in speed that might occur on less occupied streets (especially in Bangkok and Northeastern regions, whose shock dummies in section 4.2 are unexplainably insignificant positive), and so on.

- The eco-driving measure becomes more effective if other oil saving measures interact positively. For example, if the government does not insist on subsidizing/stabilizing fuel prices, does promotes carpooling, and so on, the combined measures will have a greater impact. In addition, the law enforcement system and driving etiquette should be fixed.

In addition to efforts from the government, cooperation from the private sector and participation from the civil society are very important. For instance, insurance companies can make the saving measures more successful and reduce the government's funding burdens if the insurance contracts allow buses from the tourism industry to join the transit system or vanpooling at lower costs during an emergency. Reduced insurance cost for those who take eco-driving training courses also supports the saving measure. Retail stores can participate in assistance programs and other saving measures by providing discounts for those who use public transit, carpool, bike, and walk. Investing in related facilities for telecommuting and creating a comprehensive plan for compressed workweeks cannot be done without participation from employers and employees. Additionally, information provision regarding saving measures and shortages can be done via high credibility sources such as grass-roots organizations, neighborhood groups, and respected friends. Hence, participation from non-government actors is necessary.

Chapter 5

CONCLUSION

5.1 Conclusion

This study aims to find a set of sustainable policies for Thailand to cope with oil crises in the transportation sector. The study focuses on oil saving measures, a demand-side policy, because the measures can reduce oil dependency and carbon lock-in. While fuel switching is another option, it takes time and new technology to switch. Oil saving policies thus can be either an alternative or a supporting option which can be utilized no matter what types of fuels are used. Although the study focuses on gasoline, the measures can apply to biofuels, electricity for electric vehicles, and other types of fuel. A crisis of the old days was likely to involve oil shortages, but a crisis now can also be environmental, such as pollution and contamination from mountains of battery waste, or climate change which leads to huge floods in sugarcane farms and the cloudy sky over a solar farm. In addition, a crisis could involve acts of terrorism and other unforeseen or unpredictable events that affect transportation. Conservation requires behavioral change, and this is one of the main reasons why oil saving measures are not popular.

The study is divided into 3 parts: 1) Oil Crises and Oil Saving Policies, 2) Empirical Study of Gasoline Demand in Thailand, and 3) Oil Saving Policies for Thailand. The first part looks at the experiences and guidelines regarding oil saving measures from other countries qualitatively. The second and third parts of the study pay attention to Thailand quantitatively and qualitatively. The second part of the study examines gasoline consumption and other important factors with econometric methods. The third part collects more information on Thailand from online sources, combines the information from the first and the second parts, and offers a package of oil saving measures for Thailand.

5.1.1 Conclusion of Oil Crises and Oil Saving Policies

This study examines 9 oil saving measures implemented in several countries. The analysis utilizes the energy contingency plan (Davis, 1983) with the incorporation of E4 perspectives (Johansson, 2005) and the human ecosystem model (Guerin et al., 2000). By including E4 perspectives, the plan to cope with a short-term crisis will be more sustainable in a long run. By considering energy, economy, equity, and environment, an oil saving policy can gain a higher acceptance and cooperation from people. Meanwhile, the human ecosystem model can increase effectiveness through better understanding of oil consumption and conservation by considering the interactions among the qualities of human organisms (e.g., family, occupant, gender, etc.), the natural environment (e.g., seasons, night, short daylight), the social environment (e.g., sense of comfort, cultural norms, laws), and the designed environment (e.g., public transportation infrastructure, Internet infrastructure, bike lane).

For **pricing measures**, increasing oil taxes will reduce oil consumption, especially in a country with low oil taxes (IEA, 2005b), but public resistance is high especially during a crisis (Noland et al., 2003). A subsidy is likely to exist in countries with a frail institutional capacity (Cheon et al., 2013), but these subsidies will reduce the effectiveness of other oil saving measures. Assistance programs for vulnerable groups are vital to maintain the market prices. **Public transportation enhancement** gains high support (Belk et al., 1981), but increasing the supply of buses is often done at a limited level (Davis, 1983; Cox, 1983a) and transit tends to be less convenient especially for people in areas without good transit systems, who have to transport dependents, or who must carry large items (Chatterjee & Lyons, 2002). Planning and setting up agreements with other sectors and government units are important, and providing up-to-date and easily accessible public information for regular and new riders (Davis, 1983) by multiple means of communication is required. Other measures are needed for the areas with poor transit accessibility (Hartgen & Neveu, 1980). **Carpooling** needs cooperation from the private sector, and advanced technology should be used for the matching system (IEA, 2005b) at the earliest stage of a crisis. However, illegal taxis (Wang, 2011) and private information (Furuhata et al., 2013; Bicocchi & Mamei, 2014; Friginal et al., 2014) are challenging for this measure (Furuhata et al., 2013; Bicocchi & Mamei, 2014; Friginal et al., 2014). **Telecommuting** can reduce oil consumption and overcrowded conditions on public transit. This measure requires cooperation with the private sector and infrastructure establishment in advance (IEA, 2005b; Aguilera et al., 2016; Perez et al., 2002). However, some tasks and positions are not suitable for this measure (Aguilera et al., 2016; Hamsa et al., 2016); also, non-work trips might increase (Rhee, 2008; IEA, 2005b). A **compressed workweek** does not only require cooperation with private sector, but it also needs to cooperate with public transit (Schueftan, 1983; Barker, 1983) and traffic police because of trip redistribution and narrowed peak hours (Ho & Stewart, 1992). Distribution of sleeping time might be affected (Milia, 1998), but a longer weekend is a benefit (Hung, 1996). **Rationing** is a measure used to cope with a shortage several decades ago during the implementation of the price control policy. The huge requirements of administrative work (Difiglio, 1984; Bezdek & Taylor, 1981) and cooperation between central and local governments might not ensure equity as expected (Phillips, 1945; Bezdek & Taylor, 1981). Illegal coupon markets formed (Difiglio, 1984; Horowitz, 1982) and illegally blended petroleum products (Wisansuwannakorn, 2006) were developed. These problems could occur again if the plan does not take them into consideration. Other travel options are required to maintain mobility. **Driving restrictions** are also used during a shortage, requiring increased personnel and equipment (IEA, 2005b) to enforce the laws. Although it significantly decreases oil consumption, people find the ways to circumvent the measure with some adjustment for their lifestyle, and the measure tends to be less effective in the longer term (Davis, 2008; IEA, 2005b; Wang et al., 2014; Gallego et al., 2013). Equity and economic loss are problems if other travel options are not sufficiently available. **Non-motorized modes** have other benefits which policymakers should emphasize; however, supporting infrastructure, bike and ride programs, safe environments (Santos et al., 2010; Noland & Kunreuther, 1995; Van Malderen et al., 2012; Hanson et al., 2013), maintaining high oil prices (Courtemanche, 2011), and using social aspects such as “conformity and peer effect” (Martens, 2007, p. 336) are mandatory. **Eco-driving** is a good option for those who need to drive. Eco-driving training, feedback devices (Barkenbus, 2010), aggressive campaigns (IEA, 2005b), and correcting myths (Carrico et al., 2009) will increase the effectiveness of the measure, but annoyance by other drivers, distractions, and increased travel times and emissions (IEA, 2005b; Alam & McNabola, 2014; Hartgen & Neveu, 1980) are the side effects. Eco-driving should become the norm of driving behavior for a longer-term impact (Barkenbus, 2010; Barla et al., 2017).

5.1.2 Conclusion of the Empirical Study of Gasoline Demand in Thailand

Econometric methods are employed. In order to eliminate spurious regression problems in time series data, the first difference is used, and unit roots are checked to confirm stationarity. The endogenous problem of gasoline price is examined by the Hausman Test for Endogeneity with the Brent price at local currency and the domestic diesel price as instrumental variables, but it confirms that gasoline prices in Thailand are exogenous. Panel analyses with cross-section fixed effect are done for the whole country, but due to the confusing results of each factor and each region because of the uniqueness of each region, the study relies on separated time series models by region.

Table 5.1 shows that gasoline price is inelastic especially in the Central region and Bangkok. Although there is no statistical difference in the effect of increasing price and decreasing price, the panel analysis indicates that the effect of increasing price tends to be larger. Per capita GDP positively correlates with gasoline consumption, but the North and Central regions insignificantly show the condition of inferior goods. NGV is found to be an important substitute for gasoline in several regions while switching to diesel and LPG is found in the Sothern region and Bangkok, respectively. However, the statistical data presented in Table 4.36 show higher demand for LPG in transportation during the period of high oil prices in the 2000s and the lower demand when the price declined, but the evidence is not obvious for diesel. Higher transit fares should lead to a higher demand for gasoline, but this hypothesis is not true in all regions except for the Northeastern region. This implies that the higher transit fares combined with improvements in transit service and networks might not always lead to a reduction in demand for transit. Vehicle stock has a positive correlation with gasoline consumption as expected. More industrialization leads to an insignificant reduction in gasoline consumption except for the Southern region. The reason behind this might involve urban planning or land use changes in those regions. A higher unemployment rate decreases gasoline demand in all regions except for the Southern and Central regions. A shock effect is expected to generate more savings, but it is not true for the Southern and Northeastern regions and Bangkok. Perhaps conservation campaigns needed to be revised, especially in those areas. The reason for the Southern region having several unexpected findings might be the oil smuggling from Malaysia where the government heavily subsidizes fuel prices while the unexpected results in the Central region might come from its location which is on the way to other regions. For seasonality, the fourth quarter is the peak demand of all regions except for the Southern region and Bangkok as it is the travel season in several regions. The first quarter and second quarter are the highest period for the Southern region and Bangkok, respectively.

Table 5.1 Summary of Factors Influencing Gasoline Demand by Regions

Independent Variables	TH	SR	NR	CR	NE	BK
	Panel Analysis	Time Series Analysis				
Yearly Model	Simple4/ Asym1	Simple3	Simple3	Simple3	Simple5	Simple7
C	+*	-	+*	+	+	-*
d(log(GASP))	-0.32*	-0.59*	-0.39*	-0.13	-0.38*	-0.19*
d(log(GASPCUT))	-0.19					
d(log(GASPREC))	-0.67*					
d(log(GDP))	+(0.04-0.05)	+0.05	-0.49	-0.26	+0.43	+1.20*
d(log(DIESELP))		+				
d(log(LPGP))						+*
d(log(NATGASP))	+	+	+*	+		
d(log(TRANSITP))	+*	-	-	-	+	-[1]
d(TRANSITQ)[2]						-*
d(VEHQPC)		+	+	+	+	+*
d(AGGDP%)	-*	+	-*	-	-*	-*
d(UNEMP%)	-*	+	-*	+	-	-*
OILSHOCK	-(0.03-0.04)*	+0.09	-0.02	-0.05	+9.0 e-4	+0.01
Quarterly Model	Simple4	Simple5/ Simple7	Simple7/ Asym7	Simple7	Simple7	Simple3
QUARTER1		H*			L*	L
QUARTER2		L*				H
QUARTER3	L*		L*	L*		

Independent Variables	TH	SR	NR	CR	NE	BK
	Panel Analysis	Time Series Analysis				
QUARTER4 (dropped)	H		H	H	H	
FLOOD[3]	-0.19*					-0.16*

Note * The coefficient is significant at 10%.

H is the highest demand and L is the lowest demand.

1. Only TRANSITP comes from simple model 3 of time series analysis for Bangkok with annual data

2. TRANSITQ is added in Bangkok only because of data availability.

3. FLOOD dummy is the huge flood in Bangkok during the last quarter of 2011

Besides the correlations of the important factors and gasoline consumption that are found, the empirical study reveals the differences in those correlations among the 5 regions. Policymakers should thus consider local context when national plans are made.

5.1.3 Oil Saving Policies for Thailand#

This third part of the study collects qualitative information regarding Thailand on the 9 saving measures via the most popular online discussion forum in Thailand and the articles found on Google search. The study combines this information with the evidence found in the first and the second parts of the study. Most of the forum and article opinions are consistent with the experiences and guidelines found from other countries. However, weak law enforcement, lack of driving etiquette, distrust in the government and PTT, political conflicts, lack of discipline, poor sidewalks with street vending, street crime, homeless dogs, hot summers, the rainy season, a hesitation to ride public transit or bike to work, and other factors are unique to the context for Thailand. Table 5.2 develops a summary of preparations for implementing oil saving measures and the challenging points of which policymakers should be aware.

Table 5.2 The Summary of Preparation to Implement Oil Saving Measures for Thailand

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
Pricing Measures - Implement laws to phase out and prevent fuel subsidies during a crisis - Offer assistance programs for vulnerable groups with consideration of specific characteristics of each region for example oil smuggling issues in the Southern region, the different high season of gasoline use in Bangkok, better transit system in Bangkok - Update databases to support the assistance programs; for example, the new poor who will be qualified for the assistance in each region - Provide sufficient and affordable travel options, or options to reduce trip generation, depending on each area and group's characteristics	- Prevent political unrest and economic difficulties by providing sufficient and affordable travel options - Make sure that all vulnerable groups can access and take advantage of the assistance programs - Update databases as oil prices change	- Expectation to receive fuel subsidies - Political instability, protests, and distrust in the government - Doubts about oil price structures and comparison with other countries - Concerns about prices of other goods and services - Problems with existing poverty

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Establish infrastructure for less fuel intensive travel modes and a fair budget allocation system - Proactively disseminate information to correct false information and misunderstood messages to prevent political unrest and create trust. This is very important for unstable condition in Thailand. - Increase public awareness regarding the necessity to maintain the market price. - Use the public information strategies to inform people of the available travel options and to encourage behavioral change		and competitiveness
Public Transit Enhancement - Cooperate with public transit, tourism industry, labor union, etc. to set agreements for increasing transit capacities - Improve transit infrastructure, connections, accessibility, and service, and prepare for higher demand during a crisis. This is vital	- Ensure that the vulnerable groups, disabled people, senior citizens, students, bikers, etc. can take advantage of transit as it is found that these groups in Thailand cannot take	- Hot weather and rainy season - Poor services and unsafe rides for normal people and dependents - The poor environment such as smoke from

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
because during normal circumstances, several of Thai people do not find good experience with the transit system. Higher fare with better service should be acceptable in several areas as found especially in Bangkok - Prepare information for first-time riders and regular riders - Employ information technology to reduce wait times and to provide information - Create new image of public transit by using public information strategies to target young professional groups, medium to high-income people, etc. for warm glow feeling and environmental benefits - Promote transit etiquette for passengers and drivers	advantage of the transit system even during normal circumstances. - Monitor for the side effects of other measures such as compressed workweeks which redistribute peak hours, driving restrictions which increase transit demand, non-motorized modes which need facilities for bike and ride programs, carpooling which might draw people from transit - Use fuel efficient and environmentally friendly buses as Thai people also complain about old and poor-maintained buses.	street food, poor sidewalks, etc. - Poor connections and accessibility - Public transit etiquette - Negative perception of transit riders' economic status - Higher fare but better service is acceptable for riders except for the Northeastern region

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
Carpooling - Use technology to match riders and drivers on the internet base with minimized risks of private information issues - Arrange agreements and cooperation with the internet-based matching agencies, car/van/bus rental companies, tourism companies, etc. together with employers to provide carpooling programs for employees - Cooperate with private sector to offer incentives for employers and employees to participate. This is important, as Thai people are unlikely to share ride with strangers. - Provide information about sign-up programs, incentives, etc., especially for those who cannot access public transit. This is important because several of Thai people have poor accessibility to the service. - Increase carpooling standards by setting social norms regarding carpooling etiquette	- Consider the effects of other measures. Compressed workweeks might require some adjustment for carpooling; fuel price subsidies reduce the effectiveness of carpooling - Screen and monitor private agencies participating in the program to minimize concerns over crime, safety, and private information of carpoolers as several of Thai people show concerns on these issues. - Monitor for illegal taxis and professional passengers who fill up other people's cars if	- Characteristic of being considerate and avoidance of saying "no" directly or setting rules with friends - Unsafe environment and crime which make people distrust strangers - Involvement from executive level, familiarity of employees, economic conditions, social values, and location of offices are the main success factors

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Be clear on laws and policies for ridesharing such as Uber, Lyft, etc.	high occupancy vehicles are enforced	
Telecommuting - Have employers sign up for the program and ensure the necessary infrastructure such as computer and internet access - Convince employers to invest and cooperate for several reasons not just saving oil, provide information about successful practices, information about losses if they do not do so, and commend the organizations that actively participate. Political unrests in the past and the huge flooding in Bangkok can draw employers' attention. - Target employers in Bangkok where facilities are available but invest in other regions to take advantage of the policy - Identify the designated employees, the situation that would trigger participation, the designated positions, the number of days per week to work at home, and so on	- Provide sufficient and affordable travel options because some people cannot telecommute - Monitor side effects such as burdens pushed to employees, work-life balance, non-work trip increases, electricity bills at home, feedback from employees and employers, etc., - Minimize the negative effects such as providing work-life balance and loneliness consultation, suggesting how to save electricity at home. etc.	- Believed to be less productivity at home and lack of discipline among Thai people - Expectation to see employees at the office even though there is no work - Concerns about job security, work-life balance, loneliness, career path, higher utility costs at home, etc. - Infrastructure such as computer, the Internet, security issues

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Adjust regulations to support work at home programs such as the minimum infrastructure needed, rights of employers and employees, newly incurred costs, etc. as currently there is no specific regulations promoting the measure.		
Compressed Workweeks - Cooperate with private sector, discuss and set a detailed plan with employers, and commend employers who participate. Organizations with high productivity should be targeted. - Set criteria or guidelines for employers and work with them to set up a plan to be ready to use, and identify the designated employees, working days and hours, how to contact the employees during the off-day, etc. - Amend the Labor Protection Act to allow a longer workday, especially working 10 hours during an emergency and require standards and guidelines to ensure healthy condition for the workers	- Effect on those who fampool or have other commitments - Peak hour redistribution which requires the government to work with transit operators and traffic police to manage all changes - Provide special supporting programs such as emphasizing an importance of short breaks and exercise during the day, monitoring health and safety condition, etc.	- Productivity reduces during extended hours and more doubt for government employees - Some people already work longer hours - Concern about daily workers - Concern about missing key personnel on a particular day - Laws and requirements that companies pay overtime to

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Aim to attract organizations that cannot arrange to carpools and focus on the areas and the seasons (rainy season or hot summer in Thailand) that non-motorized modes are limited		employees who work longer days
Rationing - Use the measure as a last resort - Prepare and update databases of registered vehicles and registered drivers, update priority driving database regularly - Update registered vehicles by fuels and consider advantages and disadvantages of exempting vehicles run by NGV, LPG, electricity, or other fuels - Needs huge administrative work and involvement from central government, regional government, industry, media, etc. for issuing cards/coupons, distributing them, and enforcing the measure - Increase mobility via other less fuel intensive measures. Public information is required to prepare	- High transaction and administrative costs, so funding should be addressed in advance - Make sure that people are equally treated and ensure better communication channels - A massive deficiency of data, so the laws should address the responsibility and determine penalties - Issue coupons or cards that are hard to duplicate and monitor counterfeit problems	- Illegal blended petroleum products and black markets - Questions on equity and fairness of the measure - Distrust and political instability - Counterfeit coupons or cards

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Set up a call center, smartphone applications, other communication channels to offer trip planning, information sharing, and others - Provide information involved with the severity of the crisis and the necessity to enforce the measure, with the effectiveness and fairness of the measure as Thai people usually question their government. - Identify a particular percentage of shortage and expected length of the shortage to trigger the measure	- Monitor and prevent black market coupons and petroleum products, substandard fuels, hoarding, and unfair increases in prices of goods	
Driving Restriction - The measure should be used as a last resort with a serious shortage - Install surveillance cameras and other facilities in advance - Cooperate with other government agencies, local units, traffic police, and related private sectors, and identify the details such as the designated areas, trained personnel, and possible means of violation and how to prevent and monitor them	- Create campaigns on passenger etiquette and carpool etiquette - Monitor and prevent the methods of violation and the ways to circumvent the measure such as covering plates, borrowing plates from others, simply ignoring the driving ban measure, later	- Fake license plates or just violate the restriction - Concerns about emergencies - Concerns about unequally treated groups, especially rich people, government units, other privileged groups, and taxis

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Provide sufficient and affordable less fuel intensive travel options and trip reduction measures - Provide public information to facilitate those who are unfamiliar with the new modes and use tailored information for appropriate groups - Provide information involved with the severity and the necessity to enforce the measure with the effectiveness and fairness of the measure, especially stronger law enforcement - Set up a call center, smartphone application, better communication channels to offer trip planning, information sharing, etc. - Update registered vehicles by fuels and consider advantages and disadvantages of exempting vehicles run by NGV, LPG, electricity, or other fuels	purchasing another car, and more taxi riders, and then adjust the restrictions - Monitor for difficulties, special needs, more groups to be exempted from restriction, etc., and rapidly adjust the measure	- Concerns about corruption - Concerns about fairness and equity of the measure - Beliefs that other measures might work better - The government should first improve public transit - Weak law enforcement
Non-Motorized Modes - Provide walking and cycling infrastructures and favorable environments such as crime	- Monitor for the concerns and the interactions between pedestrians/bikers and	- Poor sidewalk conditions, obstructions from street vending,

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
reduction, well-maintained sidewalks not obstructed by street vending (and others), dedicated biking lanes with strict enforcement, homeless dog reduction, and strict enforcement on motorcycles riding on sidewalks. - Ensure integrated policies such as bike and ride program (biking for health purposes and environmental benefits, not just for energy saving), walking-street vending-poverty issues, etc. - Cooperate with public transit and the city for bike and ride program, cooperate with the city/municipal for homeless dogs and street vending issues, etc. - Change attitudes of drivers, bikers, and pedestrians and create equality in transportation as the conflicts among the groups in Thailand are found. - Enforce the laws strictly such as stopping at crosswalks, removing illegal street vending, no motorcycles riding on sidewalks, no jaywalkers, etc.	drivers such as increased exposure to air pollution due to people's slow walking speed - Monitor the interactions with other saving measures; for example, good public transit and bike-friendly systems encourage more people to walk and bike to stations	motorcycles riding on sidewalks, etc. - Homeless dogs and street crimes - Hot weather and rain in Bangkok - Equality between non-motorized modes and motorized modes - Weak law enforcement

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Take seasonality into account and cooperate with public and private sectors to provide shower rooms, increase the number of big trees along sidewalks, provide roof along sidewalks, etc. - Utilize public information strategies to encourage conformity and peer effect		
Eco-Driving - Identify and update the eco-driving tips and some specific information (not only general information) for different car models, motorcycles and pickup trucks - Utilize advanced technology to inform specific information that fits drivers' needs. - Cooperate with private sector, other government units, experts, and media to disseminate information effectively via experts like engineers, scientists and practitioners - Use information content that is simple but vivid and emotionally charged	- Identify outdated information and myths that need to be fixed, and emphasize the updated and correct information to the targeted groups - Sustain eco-driving behaviors by well-planned strategy - Monitor side effects that can take place such as increasing travel times, pollution, accidents from distraction, etc.	- Provide more information about motorcycles and pick-up trucks - More specific information such as tips for specific car models, driving in urban/rural areas, etc. - Myths such as idling and other outdated information - Content and presentation

Preparation/Cooperation	Side Effects to Prevent or Monitor	Challenging Points for Thailand Context
- Set up short eco-driving training programs to be ready for a higher demand during a crisis - Prepare laws and agreements such as agreements with auto service centers to check tire pressure for free, etc., and prepare for infrastructure such as speed cameras - Pay attention to intention-action gap, not just provide oil saving tips, and target drivers in the Northeastern region and Bangkok where the shock dummy is not negative	- Consider other measures such as not subsidizing fuel prices and ensure law enforcement system and driving etiquette	format of oil saving information provided by the government are not interesting and not emotionally charged. -Infrequent and inconsistent campaigns

Note: The information is developed from the articles listed in section 4.1, the results from section 4.2, the opinions found in the online discussion forum, and the articles listed in Table 3.7, and incorporates with Energy Contingency Plan (Davis, 1983), E4 Perspectives (Johansson, 2005), Human Ecosystem Model (Guerin et al., 2000)

The applications should set the E4 perspectives as goals (maintain mobility and productivity for all but consume less oil and reduce emission) and should incorporate the understandings of the interactions among the 4 components of the human ecosystem model based on the context of Thailand.

5.2 Overall Significance

Several recommendations and evidence presented in this study come from the reviewed articles listed in section 4.1 of Chapter 4. However, this study incorporates the evidence found from econometric results presented in section 4.2 of Chapter 4 and the evidence from the online discussion forum and the articles listed in section 3.3 of Chapter 3 in order to apply to the context of Thailand.

This study draws attention to a demand-side policy in response to a crisis. In addition to promoting renewable energy, this study reminds policymakers that the saving policy is a useful strategy which does not trap a country into carbon lock-in even though the policy may only be used during a short-term crisis. Unlike other studies regarding oil saving measures, this study provides a package of saving measures with higher sustainability and effectiveness and fewer side effects by incorporating the energy contingency plan (Davis, 1983), E4 perspectives (Johansson, 2005), and the human ecosystem model (Guerin et al., 2000). Although this study focuses on gasoline, it can be applied to any type of energy with some adaptation.

Specifically for Thailand, the study provides a package of oil saving measures that policymakers can implement more effectively and that will gain higher public acceptance than current oil saving policies. The study also contributes to the transportation sector and consumers in the nation because of the attempts to minimize negative impacts and to better understand these issues in the specific context of Thailand. Through this study, policymakers can understand the correlations between a variety of important factors and gasoline consumption at both the national and regional levels via the econometric method. Besides the quantitative method, this study initiates the utilization of a non-academic source, namely the online discussion forum, as well as the academic evidence in articles. In addition to the application of the experiences of other nations to the unique context of Thailand, other oil-importing developing countries can take advantage of these methodologies for their own saving measures.

5.3 Further Study and Moving Forward

5.3.1 Limitations and Further Study

This study provides extensive reviews of oil saving measures from different countries, and also looks at Thailand quantitatively via econometric methods and qualitatively via evidence from the online discussion forum and articles. The contribution of the study is to assist policymakers to implement oil saving measure mores effectively and for the longer term, and to receive higher public acceptance. However, the study has certain limitations, and further study should focus on 3 issues.

Because the government should respond the crisis differently among areas (city, suburbs, rural), incomes (low, medium, high), and situations (when the crisis hits, as the crisis subsides, and when prices increase quickly) (Hartgen et al., 1983), having information and understanding the impacts on those different groups will help the government implements a more appropriate package of policies. Because of the limitations of data availability, the second part of the study attempts to look at Thailand at a regional level instead of the national level like other studies. However, data about fuel consumption by areas of development, incomes, and so on are not available. **An intensive survey with the ability to differentiate people's behavior and impacts of a**

crisis in different cohorts is recommended for further study. Additionally, **microscopic models** could be employed to gain more information at the individual level. This requires significant time, personnel, and budget.

Another study which should be done in the future is an examination of how to **improve cooperation and coordination** among government units, local and central governments, and between the government and the private sector. The 9 oil saving measures require considerable cooperation among several units such as the Ministry of Energy, the Ministry of Public Health, the Ministry of Labor, the Ministry of Transport, traffic police, transit operators, employers, local governments, and so on.

During a future crisis or high oil price period, researchers should take advantage of the situation to study and survey the impacts and find out how people actually adjust themselves. Such a study will gain the fresh memories and increase accuracy. A survey during a crisis or just a few months after a crisis is likely to get information about what people actually do, instead of the information from their opinions and plans if a crisis hits. In contrast to stated preference methods, decision-making and judgment biases in revealed preference methods are minimized.

5.3.2 Preparation for Electric Vehicles

Although the study focuses on saving oil or gasoline, several of the findings and recommendations can be applied to biofuels which are planned to penetrate Thailand based on the AEDP 2015. An important difference between gasoline and ethanol is that ethanol is domestically produced. A shortage or high ethanol prices due to non-weather reasons (such as speculation, mismanagement, etc.) might lead to conflicts between domestic producers and consumers and less acceptance of saving measures. More details on saving measures should be researched, especially when ethanol plays a more important role.

Recently, the Thai government has tried to promote electric vehicles through tax measures, demand from the public sector, studies for infrastructure, studies for battery waste management, human resource development, and so on. The government expects electric cars and electric motorcycles in Bangkok and vicinity to comprise around 7% and 1% of total cars and total motorcycles respectively by 2036 (Energy Policy and Planning Office, 2015a). Similar to fuel-efficient vehicles, which were claimed to be a major oil saver during the late 1970s and the early 1980s (Hartgen & Neveu, 1980), electric vehicles will play an important role during a future crisis of high oil prices. This will be advantageous for those who can afford electric vehicles, but those who cannot will need to rely on assistance programs and other less fuel intensive travel modes.

However, if electric vehicles highly penetrate Thailand and the electricity supply is disrupted for any reason, electricity saving measures will play a crucial role. Future studies should examine how to cope with electricity disruptions, which will be more challenging and complex because household, transportation, industry and commercial sectors all rely on electricity. For **pricing measures**, subsidizing renewable energy for electricity generation will reduce the effectiveness of other saving measures. Meanwhile, fossil fuels tend to be cheaper when transportation and other sectors switch to electricity. This dilemma can create another headache for policymakers. **Public transit enhancement and carpooling** can still help conserve electricity, but the advanced technology used to support the system can be vulnerable because of its electricity dependency. **Telecommuting** might not gain as much acceptance because working from home increases the burden of electricity bills on employees although travel costs are reduced. **Compressed workweeks** become an important measure to reduce trip generation. **Rationing** might be more complicated because it is hard to separate electricity for vehicles and electricity for household appliances. Rationing by household can be easy but equity (between small and big households) might be questioned while rationing by person is hard to do in practice as electric meter boxes are installed at each household, not for each person. An accurate database of the number of persons in a household will be required. **Driving restrictions** do not differ from the measure in the case of oil. Again, providing several travel options are mandatory. **Non-motorized modes** will still be important for conserving electricity; however, an increase in electric bicycles might reduce the effectiveness of the measure. **Eco-driving** will require a new set of knowledge because saving tips for electric vehicles are different from the ones for the internal combustion engine. Correcting myths and providing updated information for drivers to take the most advantage of advanced technology are important.

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Appendix

Appendix A

THAILAND ENERGY FLOWS 2016

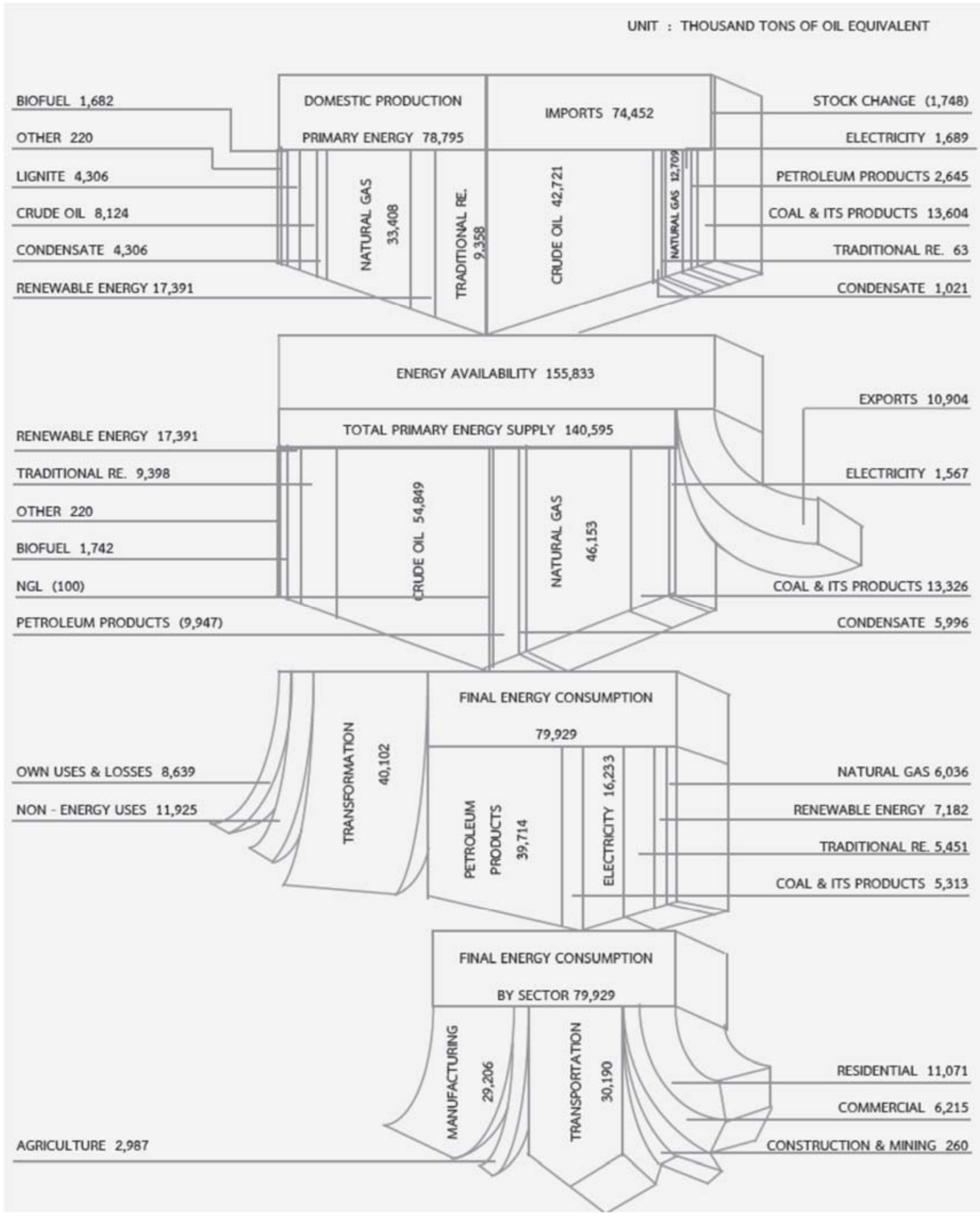

Figure A1. Thailand Energy Flows 2016 (Source: DEDE, 2016)

Appendix B

SUMMARY OF LITERATURE

FOR EMPIRICAL STUDY OF GASOLINE DEMAND

Table B1. Summary of Literature for Empirical Study of Gasoline Demand

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
Lin & Zeng, 2013	1997-2008 China	Static	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income				
	1997-2008 China	Static and instrument variable	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income				
	1997-2008 China	Static	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Interaction of real price of gasoline and per capita real disposable income			
	1997-2008 China	Static and instrument variable	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Interaction of real price of gasoline and per capita real disposable income	Regional diesel prices and international crude oil prices as instruments.		
	1997-2008 China	Static and macro variable	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Real interest rate			

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
	1997-2008 China	Static and macro variable	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Unemploy ment rate			
	1997-2008 China	Static and macro variable	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Real interest rate	Unemploy ment rate		
	1997-2008 China	Dynamic	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Ln lagged per capita gasoline demand			
	1997-2008 China	Dynamic and instrument variable	Ln of per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income	Ln lag per capita gasoline demand			
	1997-2008 China	Static	VMT per capita	Ln real price of gasoline	Ln per capita real disposable income				
	1997-2008 China	Static and instrument variable	VMT per capita	Ln real price of gasoline	Ln per capita real disposable income	Ln per capita real GDP			
Dahl, 2012	2006 Several countries including Thailand	Static	Ln per capita gasoline demand	Ln real price of gasoline					

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
Hughes, Knittel & Sperling, 2008	1975-1980 2001-2006 U.S.	Static	Ln per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income				11 month dummies
Iwayemi, Adenikinju & Babatunde, 2010	1977-2006	Dynamic, Cointegration	Ln gasoline consumption	Ln real price of gasoline	Ln per capita real GDP				
	1977-2006	Dynamic, Cointegration	Difference in ln gasoline consumption	Difference in ln lagged real price of gasoline	Difference in ln lagged per capita GDP	Difference in ln gasoline consumption	Ecm term		
Saad, 2009	1970-2005 Indonesia	Dynamic, Cointegration (bound test)	Ln per capita gasoline and diesel demand	Ln real prices of petroleum products	Ln per capita real GDP	Time trend			
	1970-2005 Indonesia	Dynamic, Cointegration (bound test)	Difference in ln per capita gasoline and diesel demand	Difference in ln real prices of petroleum products	Difference in ln per capita real GDP	Difference in ln lagged prices of petroleum products	Difference in ln lagged per capita real GDP	Ecm term	
	1970-2005 Indonesia	Dynamic, Cointegration (bound test)	Ln per capita gasoline demand	Ln real price of gasoline	Ln per capita real GDP	Time trend			
	1970-2005 Indonesia	Dynamic, Cointegration (bound test)	Difference in ln per capita gasoline demand	Difference in ln price of gasoline	Difference in ln per capita real GDP	Difference in ln lagged per capita gasoline demand	Ecm term		

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
Akinboade, Ziramba & Kuma, 2008	1978-2005 South Africa	Dynamic, Cointegration	Ln per capita gasoline demand	Ln real price of gasoline	Ln per capita real disposable income				
	1978-2005 South Africa	Dynamic, Cointegration	Difference in ln per capita gasoline demand	Difference in ln real price of gasoline	Difference in ln lagged per capita real disposable income	Difference in ln lagged real price of gasoline	Lagged per capita real disposable income	Ln lagged per capita gasoline demand	Difference in ln lagged gasoline demand
Alves & Bueno, 2003	1984-1999 Brazil	Dynamic, Conintegration	Ln per capita gasoline demand	Ln real price of gasoline	Ln per capita real GDP	Ln real price of alcohol	Time trend, and time trend^2		
	1984-1999 Brazil	Dynamic, Conintegration	Difference in ln per capita gasoline demand	Difference in ln real price of gasoline	Difference in ln per capita real GDP	Difference in ln real price of alcohol	Time trend		
Gately & Huntington, 2002	1971-1997 OECD countries	Symmetric	Ln per capita oil demand	Ln real price of crude oil	Ln per capita real GDP				
	1971-1997 OECD countries	Asymmetric	Ln per capita oil demand	Ln real price of crude oil	Ln per capita real GDP	Ln lagged oil demand			
	1971-1997 OECD countries	Asymmetric	Ln per capita oil demand	Ln real Pmax/Pcut/ Prec	Ln per capita real GDPmax/ GDPcut/ GDPrec	Ln lagged real Pmax/Pcut/ Prec	Ln lagged per capita real GDPmax/ GDPcut/	Ln lagged per capita oil demand	

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
							GDPrec		
	1971-1997 Non OECD income grower	Symmetric	Ln per capita oil demand	Ln real price of crude oil	Ln per capita real GDP	Ln lagged per capita real GDP			
	1971-1997 Non OECD income grower	Symmetric	Ln per capita oil demand	Ln real price of crude oil	Ln per capita real GDP	Ln lagged per capita oil demand			
	1971-1997 Non OECD income grower	Asymmetric	Ln per capita oil demand	Ln real Pmax/Pcut/ Prec	Ln per capita real GDPmax/ GDPcut/ GDPrec	Ln lagged real Pmax/Pcut/ Prec	Ln lagged per capita real GDPmax/ GDPcut/ GDPrec	Ln lagged per capita oil demand	
Dargay & Gately, 1997	1961-1990 11 OECD countries	Symmetric	Ln per capita fuel demand	Ln lagged real price of fuels	Ln lagged per capita real GDP	Ln lagged per capita fuel demand			1974 dummy
	1961-1990 11 OECD countries	Asymmetric	Ln per capita fuel demand	Ln lagged real Pmax/Prec +cut	Ln lagged per capita real GDP	Ln lagged per capita fuel demand			1974 dummy
Bentzen, 1994	1948-1991 Denmark	Dynamic, Cointegration	Ln per capita gasoline demand	Ln real price of gasoline		Ln per capita vehicle stock	Time trend		

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
	1948-1991 Denmark	Dynamic, Cointegration	Difference in ln per capita gasoline demand	Difference in ln price of gasoline		Difference in ln lagged per capita gasoline demand	Difference in ln per capita vehicle stock		
	1948-1973 1974-1991 Denmark Structural test	Dynamic, Cointegration	Difference in ln per capita gasoline demand	Difference in ln price of gasoline		Difference in ln lagged per capita gasoline demand	Difference in ln per capita vehicle stock		
Leesombat piboon & Joutz, 2010	1981-2007 Thailand	Dynamic, Cointegration 7 economic sector separately	Difference in ln oil consumption	Difference in ln weighted real price of petroleum products and its lag	Difference in ln real GDP and its lag	Difference in ln lagged oil consumption	Difference in ln electricity price and its lag	Difference in ln real capital stock and its lag and difference in ln labor employment and its lag	
	1981-2007 Thailand	Dynamic, Cointegration Panel	Difference in ln oil consumption	Difference in ln weighted real price of petroleum products	Difference in ln real GDP	Difference in ln lagged oil consumption	Difference in ln electricity price	Difference in ln real capital stock and difference in ln labor employment	6 sector dummies

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
Gately, 1993	1994-1990 U.S.	Symmetric	Ln oil demand for transport	Ln lagged real price of oil	Ln real GNP	Ln lagged gasoline demand			1974 and 1979 dummies
	1949-1990 U.S.	Asymmetric	Ln oil demand for transport	Ln lagged real Pmax/Prec/ Pcut	Ln real GNP	Ln lagged gasoline demand	Ln number of drivers		
	1994-1990 U.S.	Asymmetric	Ln oil demand for transport	Ln lagged real Pmax+rec/ Pcut	Ln real GNP	Ln lagged gasoline demand	Ln number of drivers		
	1960-1988 Japan	Symmetric	Ln oil demand for transport	Ln lagged real price of oil	Ln real GNP	Number of vehicles			
	1960-1988 Japan	Asymmetric	Ln oil demand for transport	Ln lagged real Pmax+rec/ Pcut	Ln real GNP	Number of vehicles			
	1972-1988 Japan	Asymmetric	Ln oil demand for transport	Ln lagged real price of oil	Ln real GNP	Ln lagged gasoline demand	Ln number of vehicles		
	1972-1988 Japan	Asymmetric	Ln oil demand for transport	Ln lagged real Pmax+rec/ Pcut	Ln real GNP	Ln lagged gasoline demand	Ln number of vehicles		
Gately, 1992	1966-1989 U.S.	Symmetric	Ln VMT per driver	Ln real price of gasoline	Ln real GNP per driver	Time trend			1974 and 1979 dummies

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
				per mile per gallon					
	1966-1989 U.S.	Asymmetric	Ln VMT per driver	Ln real Pmax/Prec/ Pcut	Ln real GNP per driver	Time trend			1974 and 1979 dummies
	1966-1989 U.S.	Symmetric	Mile per gallon	Ln lagged real price of gasoline					
	1966-1989 U.S.	Asymmetric	Mile per gallon	Ln lagged real Pmax/Prec/ Pcut					
	1966-1989 U.S.	Asymmetric	Mile per gallon	Ln real Pcut+rec		Ln lagged real Pmax/Pcut+ rec			
	1960-1990 U.S.	Symmetric	Ln gasoline demand per driver	Ln real price of gasoline	Ln real GNP per driver	Ln lagged gasoline demand per driver			1974 and 1979 dummies
	1960-1990 U.S.	Asymmetric	Ln gasoline demand per driver	Ln real Pmax/Pcut/ Prec	Ln real GNP per driver	Ln lagged gasoline demand per driver			1974 and 1979 dummies
	1960-1990 U.S.	Asymmetric	Ln gasoline demand per driver	Ln real Pmax+rec/ Pcut	Ln real GNP per driver	Ln lagged gasoline demand per driver			1974 and 1979 dummies

Table B1. Summary of Literature for Empirical Study of Gasoline Demand (continued)

Authors, Year	Data Period/ Area	Model	Dependent Variable	Independent Variables					
				Price	Income	Others	Others	Others	Dummy
	1960-1990 U.S.	Asymmetric	Ln gasoline demand per driver	Ln real Pmax/Pcut +rec	Ln real GNP per driver	Ln lagged gasoline demand per driver			1974 and 1979 dummies

Note: Not include meta-analysis literature

Appendix C

REGRESSION RESULTS OF EMPIRICAL STUDY OF GASOLINE DEMAND IN THAILAND

List of Variable Definitions Used in Appendix C

GASQPC	Per capita gasoline consumption per day
GASP	Real gasoline price
OILP	Real Brent crude price
GDP	Gross domestic product (chain volume measures with 2002 as reference year)
DIESELP	Real diesel price
LPGP	Real liquefied petroleum gas price
NATGASP	Real natural gas price
TRANSITP	CPI of public transportation service
TRANSITQ	Public transportation ridership
VEHQPC	Vehicles or vehicle stock per person
NEWVEHQPC	New vehicles per person
VEHP	CPI of vehicle purchase
AGGDP%	Proportion of GDP from non-agricultural sector over total GDP
UNEMP%	Unemployment rate
QUARTER1	Seasonal dummy (first quarter)
QUARTER2	Seasonal dummy (second quarter)
QUARTER3	Seasonal dummy (third quarter)
OILSHOCK	Oil shock dummy
FLOOD	Flood dummy in Bangkok in 2011

List of Tables in Appendix C

Table C1. Panel Analysis for 5 Regions in Thailand with Annual Data, 2004-2015, Simple Models 1-6

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	Simple3	**Simple4**	Simple5	Simple6	
C	**0.0344** ***0.00***	0.0162 *0.26*	0.0109 *0.46*	**0.0304** ***0.00***	0.0211 *0.01*	0.0188 *0.05*	
d(log(GASP))	**-0.3649** ***0.00***	-0.3433 *0.00*	-0.3538 *0.01*	**-0.3233** ***0.00***	-0.3201 *0.00*	-0.3091 *0.01*	
d(log(GDP))	**0.1991** ***0.44***	0.1630 *0.51*	0.1457 *0.56*	**0.0357** ***0.85***	-0.0219 *0.90*	-0.0071 *0.97*	
d(log(DIESELP))	**-0.0890** ***0.00***	-0.1465 *0.00*	-0.1135 *0.03*	**-0.1137** ***0.00***	-0.1468 *0.00*	-0.1339 *0.00*	
D(log(DIESELP)/ log(GASP))							
d(log(LPGP))	**-0.1567** ***0.49***	-0.0227 *0.93*	0.0832 *0.78*	**-0.0420** ***0.89***	6.9e-5 *0.99*	0.0971 *0.78*	
D(log(LPGP)/ log(GASP))							
d(log(NATGASP))	**0.1221** ***0.47***	0.0321 *0.87*	0.0314 *0.86*	**0.1065** ***0.55***	0.0595 *0.76*	0.0557 *0.77*	
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	**0.2384** ***0.00***	0.2674 *0.00*	0.2212 *0.00*	**0.2630** ***0.00***	0.2800 *0.00*	0.2588 *0.00*	
d(VEHQPC)	**-1.5644** ***0.00***			**-0.9142** ***0.00***			
d(log(VEHP))			0.0092 *0.03*			0.0022 *0.73*	
d(NEWVEHQPC)		1.4199 *0.13*			1.8802 *0.03*		
d(AGGDP%)	**-0.0087** ***0.14***	-0.0050 *0.51*	-0.0067 *0.36*	**-0.0087** ***0.01***	-0.0069 *0.07*	-0.0079 *0.05*	
d(UNEMP%)	**-0.0707** ***0.00***	-0.0663 *0.00*	-0.0754 *0.00*	**-0.0724** ***0.00***	-0.0639 *0.01*	-0.0787 *0.01*	
OILSHOCK	**-0.0423** ***0.00***	-0.0263 *0.00*	-0.0214 *0.02*	**-0.0381** ***0.00***	-0.0280 *0.00*	-0.0282 *0.01*	
Adjusted R-squared	**0.6214**	0.5564	0.5595	**0.6650**	0.6570	0.6446	
F-Statistic	**10.6819** ***0.00***	8.4002 *0.00*	8.4943 *0.00*	**9.3667** ***0.00***	9.0734 *0.00*	8.6451 *0.00*	
DW-Stat	**1.0694**	0.9136	0.8990	**1.2418**	1.2491	1.2386	
AIC	**-3.4338**	-3.2754	-3.2825	**-3.5081**	-3.4846	-3.4491	
Redundant Cross-section F-test				**2.5970** ***0.05***	4.5944 *0.00*	3.9347 *0.01*	
CS Fixed Effect SR CS Fixed Effect NR CS Fixed Effect CR CS Fixed Effect NE CS Fixed Effect BK				**-0.0050** **0.0069** **-0.0006** **0.0265** **-0.0279**	-0.0044 0.0080 0.0025 0.0308 -0.0369	-0.0038 0.0078 0.0025 0.0293 -0.0358	

Table C2. Panel Analysis for 5 Regions in Thailand with Annual Data, 2004-2015, Simple Model 7

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables				
	Simple7	Simple7 (Cont.)		Simple7 (Cont.)	
C	**0.0136** ***0.76***				
d(logGASP)*DSR	**-0.6690** ***0.00***	d(logNATGASP) *DSR	**0.2023** ***0.00***	d(UNEMP%)*DSR	**-0.0409** ***0.87***
d(logGASP)*DNR	**-0.2390** ***0.24***	d(logNATGASP) *DNR	**0.3619** ***0.00***	d(UNEMP%)*DNR	**-0.1440** ***0.00***
d(logGASP)*DCR	**-0.1284** ***0.12***	d(logNATGASP) *DCR	**0.2266** ***0.56***	d(UNEMP%)*DCR	**-0.0216** ***0.81***
d(logGASP)*DNE	**-0.6000** ***0.00***	d(logNATGASP) *DNE	**0.1204** ***0.46***	d(UNEMP%)*DNE	**0.1807** ***0.05***
d(logGASP)*DBK	**-0.0060** ***0.96***	d(logNATGASP) *DBK	**-0.3872** ***0.05***	d(UNEMP%)*DBK	**-0.0449** ***0.52***
d(logGDP)*DSR	**0.3104** ***0.01***	d(logTRANSITP) *DSR	**-0.1226** ***0.89***	OILSHOCK*DSR	**0.0156** ***0.87***
d(logGDP)*DNR	**-0.4887** ***0.00***	d(logTRANSITP) *DNR	**-0.0570** ***0.84***	OILSHOCK*DNR	**-0.0021** ***0.97***
d(logGDP)*DCR	**-0.4890** ***0.44***	d(logTRANSITP) *DCR	**-0.0038** ***0.99***	OILSHOCK*DCR	**-0.0271** ***0.19***
d(logGDP)*DNE	**1.2894** ***0.00***	d(logTRANSITP) *DNE	**0.0688** ***0.00***	OILSHOCK*DNE	**0.0076** ***0.83***
d(logGDP)*DBK	**0.7729** ***0.03***	d(logTRANSITP) *DBK	**0.4586** ***0.00***	OILSHOCK*DBK	**-0.0483** ***0.13***
d(logDIESELP) *DSR	**0.1872** ***0.73***	d(VEHQPC)*DSR	**-1.6807** ***0.58***	Adjusted R-squared	**0.7789**
d(logDIESELP) *DNR	**-0.1663** ***0.14***	d(VEHQPC)*DNR	**1.3996** ***0.60***	F-Statistic	**5.1577** ***0.01***
d(logDIESELP) *DCR	**-0.0924** ***0.00***	d(VEHQPC)*DCR	**3.8708** ***0.49***	Durbin-Watson Stat	**2.1816**
d(logDIESELP) *DNE	**0.3038** ***0.02***	d(VEHQPC)*DNE	**1.5762** ***0.66***	Akaike Info Criterion	**-4.3332**
d(logDIESELP) *DBK	**-0.3123** ***0.00***	d(VEHQPC)*DBK	**-0.7874** ***0.40***	Redundant Cross-section F-test	
d(logLPGP)*DSR	**0.0517** ***0.86***	d(AGGDP%) *DSR	**-0.0112** ***0.75***	CS Fixed Effect SR CS Fixed Effect NR CS Fixed Effect CR CS Fixed Effect NE CS Fixed Effect BK	
d(logLPGP)*DNR	**-0.0793** ***0.04***	d(AGGDP%) *DNR	**-0.0040** ***0.83***		
d(logLPGP)*DCR	**0.0494** ***0.92***	d(AGGDP%) *DCR	**0.0370** ***0.67***		
d(logLPGP)*DNE	**-1.1502** ***0.03***	d(AGGDP%) *DNE	**0.0070** ***0.02***		
d(logLPGP)*DBK	**0.7970** ***0.07***	d(AGGDP%) *DBK	**-6.8456** ***0.07***		

Table C3. Panel Analysis for 5 Regions in Thailand with Annual Data, 2004-2015, Simple Model 8

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables				
	Simple8	Simple8 (Cont.)		Simple8 (Cont.)	
C	-0.1098 *0.00*				
d(logGASP)*DSR	-3.2749 *0.00*	d(logNATGASP) *DSR	1.0215 *0.00*	d(UNEMP%)*DSR	4.0067 *0.00*
d(logGASP)*DNR	-0.1777 *0.00*	d(logNATGASP) *DNR	0.3738 *0.00*	d(UNEMP%)*DNR	-0.1535 *0.00*
d(logGASP)*DCR	0.0912 *0.00*	d(logNATGASP) *DCR	1.3177 *0.00*	d(UNEMP%)*DCR	0.2341 *0.00*
d(logGASP)*DNE	-0.5959 *0.00*	d(logNATGASP) *DNE	0.1769 *0.00*	d(UNEMP%)*DNE	0.2096 *0.00*
d(logGASP)*DBK	-0.1121 *0.00*	d(logNATGASP) *DBK	-0.5308 *0.00*	d(UNEMP%)*DBK	-0.1001 *0.00*
d(logGDP)*DSR	1.7977 *0.00*	d(logTRANSITP) *DSR	-14.8484 *0.00*	OILSHOCK*DSR	1.5282 *0.00*
d(logGDP)*DNR	-0.4927 *0.00*	d(logTRANSITP) *DNR	-0.1456 *0.00*	OILSHOCK*DNR	0.0132 *0.00*
d(logGDP)*DCR	1.2774 *0.00*	d(logTRANSITP) *DCR	-0.6639 *0.00*	OILSHOCK*DCR	-0.0830 *0.00*
d(logGDP)*DNE	1.3218 *0.00*	d(logTRANSITP) *DNE	0.0752 *0.00*	OILSHOCK*DNE	-0.0051 *0.00*
d(logGDP)*DBK	0.5304 *0.00*	d(logTRANSITP) *DBK	0.4237 *0.00*	OILSHOCK*DBK	-0.0240 *0.00*
d(logDIESELP) *DSR	8.8397 *0.00*	d(VEHQPC)*DSR	46.1033 *0.00*	Adjusted R-squared	0.8827
d(logDIESELP) *DNR	-0.1997 *0.00*	d(VEHQPC)*DNR	2.2269 *0.00*	F-Statistic	9.2249 *0.01*
d(logDIESELP) *DCR	-0.0492 *0.00*	d(VEHQPC)*DCR	-11.7660 *0.00*	Durbin-Watson Stat	2.8482
d(logDIESELP) *DNE	0.3417 *0.00*	d(VEHQPC)*DNE	0.3248 *0.00*	Akaike Info Criterion	-5.4217
d(logDIESELP) *DBK	-0.2853 *0.00*	d(VEHQPC)*DBK	-0.0362 *0.00*	Redundant Cross-section F-test	2.9918 *0.13*
d(logLPGP)*DSR	4.7037 *0.00*	d(AGGDP%) *DSR	0.5456 *0.00*	CS Fixed Effect SR	-0.5845
d(logLPGP)*DNR	-0.0897 *0.00*	d(AGGDP%) *DNR	0.0018 *0.00*	CS Fixed Effect NR	0.1096
d(logLPGP)*DCR	-1.2610 *0.00*	d(AGGDP%) *DCR	-0.2068 *0.00*	CS Fixed Effect CR	0.2482
				CS Fixed Effect NE	0.1391
				CS Fixed Effect BK	0.0877
d(logLPGP)*DNE	-1.3071 *0.00*	d(AGGDP%) *DNE	0.0061 *0.00*		
d(logLPGP)*DBK	1.1234 *0.00*	d(AGGDP%) *DBK	-4.1154 *0.00*		

Table C4. Panel Analysis for 5 Regions in Thailand with Annual Data, 2004-2015,
Simple Models 9 & 10, IV Model 1, and Asymmetric Models 1 & 2

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple9	Simple10	IV1	**Asym1**	**Asym2**		
C	0.0297 *0.00*	0.0279 *0.01*	0.0303 *0.00*	**0.0529** ***0.00***	**0.0243** ***0.02***		
d(log(GASP))	-0.3281 *0.00*	-0.2843 *0.00*	-0.3166 *0.17*				
d(log(GASPCUT))				**-0.1873** ***0.12***	**-0.2823** ***0.01***		
d(log(GASPREC))				**-0.6755** ***0.00***	**-0.4023** ***0.00***		
d(log(GDP))	0.0955 *0.70*	-0.0605 *0.70*	0.0329 *0.90*	**0.0490** ***0.82***	**-0.0370** ***0.84***		
d(log(DIESELP))		-0.1094 *0.00*	-0.1182 *0.23*	**-0.0388** ***0.03***	**-0.1346** ***0.00***		
d(log(DIESELP))*DSR	-0.1575 *0.00*						
d(log(DIESELP))*DNR	-0.1599 *0.00*				ǂ		
d(log(DIESELP))*DCR	-0.1504 *0.02*				ǂ		
d(log(DIESELP))*DNE	0.0052 *0.87*				ǂ		
d(log(DIESELP))*DBK	-0.0842 *0.03*				ǂ		
d(log(LPGP))	-0.0718 *0.84*		-0.0454 *0.88*	**-0.2868** ***0.33***	**-0.0212** ***0.95***		
d(log(LPGP))*DSR		0.2965 *0.22*					
d(log(LPGP))*DNR		-0.1160 *0.63*					
d(log(LPGP))*DCR		0.0941 *0.67*					
d(log(LPGP))*DNE		-0.8292 *0.00*					
d(log(LPGP))*DBK		0.1657 *0.45*					
d(log(NATGASP))	0.1089 *0.57*	0.1309 *0.44*	0.1108 *0.67*	**0.3313** ***0.06***	**0.1026** ***0.61***		
d(log(TRANSITP))	0.2528 *0.00*	0.2195 *0.00*	0.2664 *0.00*	**0.2318** ***0.00***	**0.2774** ***0.00***		
d(VEHQPC)	-0.9278 *0.00*	-0.6801 *0.00*	-0.9094 *0.00*	**-1.7113** ***0.00***			
d(NEWVEHQPC)					**1.7e-7** ***0.09***		
d(AGGDP%)	-0.0084 *0.01*	-0.0007 *0.81*	-0.0086 *0.04*	**-0.0059** ***0.04***	**-0.0064** ***0.09***		
d(UNEMP%)	-0.0649 *0.04*	-0.0449 *0.08*	-0.0720 *0.02*	**-0.0751** ***0.00***	**-0.0683** ***0.00***		

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple9	Simple10	IV1	**Asym1**	**Asym2**		
OILSHOCK	-0.0372	-0.0308	-0.0383	**-0.0326**	**-0.0252**		
	0.00	*0.00*	*0.00*	***0.00***	***0.00***		
Adjusted R-squared	0.6592	0.7451	0.6650	**0.6897**	**0.6478**		
F-Statistic	7.3399	10.5822	7.3377	**9.7427**	**8.2359**		
	0.00	*0.00*	*0.00*	***0.00***	***0.00***		
DW-Stat	1.3508	1.3655	1.2400	**1.3262**	**1.2548**		
Akaike Info Criterion	-3.4506	-3.7411		**-3.5738**	**-3.4473**		
Redundant Cross-section F-test	2.2639	5.1400		**1.8704**	**4.4441**		
	0.08	*0.00*		***0.13***	***0.00***		
CS Fixed Effect SR	-0.0043	-0.0113	-0.0051	**-0.0066**	**-0.0042**		
CS Fixed Effect NR	0.0081	0.0065	0.0069	**0.0049**	**0.0079**		
CS Fixed Effect CR	0.0003	-0.0018	-0.0006	**-0.0033**	**0.0021**		
CS Fixed Effect NE	0.0238	0.0375	0.0267	**0.0245**	**0.0309**		
CS Fixed Effect BK	-0.0279	-0.0309	-0.0279	**-0.0196**	**-0.0368**		
Instrument Variable			log(OILP)				
Hausman Test for Endogeneity (resid)			*0.97*				
Wald Test (H0: GASPCUT =GASPREC)				***0.00***	***0.31***		

Table C5. Panel Analysis for 5 Regions in Thailand with Quarterly Data, 2003-2015, Simple Models 1-6

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	**Simple4**	Simple5	Simple6	
C	**0.0313** ***0.04***	0.0254 *0.14*	**0.0320** ***0.01***	**0.0330** ***0.01***	0.0262 *0.08*	0.0296 *0.03*	
d(log(GASP))	**-0.1953** ***0.01***	-0.1836 *0.02*	**-0.1936** ***0.01***	**-0.2164** ***0.00***	-0.1824 *0.01*	-0.2124 *0.00*	
d(log(GDP))	**0.0358** ***0.85***	0.0850 *0.66*	**-0.0382** ***0.82***	**0.0268** ***0.88***	0.0146 *0.93*	0.0708 *0.69*	
d(log(DIESELP))	**-0.0197** ***0.68***	-0.0293 *0.52*	**-0.0197** ***0.69***	**0.0002** ***0.99***	-0.0280 *0.54*	-0.0016 *0.98*	
D(log(DIESELP)/ log(GASP))							
d(log(LPGP))	**-0.2689** ***0.30***	-0.2525 *0.36*	**-0.2609** ***0.31***	**-0.2529** ***0.34***	-0.2469 *0.37*	-0.2455 *0.38*	
D(log(LPGP)/ log(GASP))							
d(log(NATGASP))	**0.2031** ***0.00***	0.2062 *0.00*	**0.2044** ***0.00***	**0.1832** ***0.02***	0.2083 *0.00*	0.1843 *0.03*	
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	**0.0994** ***0.61***	0.1159 *0.49*	**0.1028** ***0.62***	**0.0892** ***0.68***	0.1164 *0.52*	0.0933 *0.64*	
d(log(VEHP))		-0.0002 *0.98*			-0.0013 *0.86*	-0.0019 *0.77*	
d(NEWVEHQPC)	**7.6827** ***0.01***		**7.7305** ***0.01***	**5.3153** ***0.08***			
d(AGGDP%)	**0.0047** ***0.32***	0.0053 *0.21*	**0.0043** ***0.20***	**0.0039** ***0.18***	0.0050 *0.09*	0.0045 *0.08*	
d(UNEMP%)	**-0.0049** ***0.66***	-0.0064 *0.52*	**-0.0046** ***0.68***	**-0.0072** ***0.48***	-0.0061 *0.54*	-0.0084 *0.35*	
OILSHOCK	**-0.0098** ***0.11***	-0.0096 *0.14*	**-0.0099** ***0.10***	**-0.0113** ***0.03***	-0.0097 *0.13*	-0.0113 *0.03*	
QUARTER1	**-0.0284** ***0.28***	-0.0132 *0.54*	**-0.0289** ***0.28***	**-0.0252** ***0.34***	-0.0138 *0.53*	-0.0152 *0.48*	
QUARTER2	**-0.0189** ***0.14***	-0.0163 *0.25*	**-0.0189** ***0.14***	**-0.0205** ***0.07***	-0.0165 *0.25*	-0.0191 *0.12*	
QUARTER3	**-0.0531** ***0.01***	-0.0487 *0.04*	**-0.0531** ***0.01***	**-0.0549** ***0.01***	-0.0489 *0.05*	-0.0525 *0.02*	
FLOOD				**-0.1923** ***0.00***		-0.2145 *0.00*	
Adjusted R-squared	**0.2283**	0.2063	**0.2237**	**0.2612**	0.2010	0.2511	
F-Statistic	**6.7810** ***0.00***	6.0773 *0.00*	**5.3042** ***0.00***	**5.9878** ***0.00***	4.7592 *0.00*	5.7320 *0.00*	
DW-Stat	**2.6383**	2.6887	**2.6702**	**2.5934**	2.7191	2.6098	
AIC	**-3.0338**	-3.0056	**-3.0131**	**-3.0590**	-2.9844	-3.0455	
Redundant Cross-section F-test			**0.6375** ***0.64***	**0.3809** ***0.82***	0.6050 *0.66*	0.3508 *0.84*	

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	**Simple4**	Simple5	Simple6	
CS Fixed Effect SR			**-0.0022**	**-0.0028**	-0.0022	-0.0029	
CS Fixed Effect NR			**0.0021**	**0.0014**	0.0021	0.0014	
CS Fixed Effect CR			**0.0008**	**0.0002**	0.0009	0.0002	
CS Fixed Effect NE			**0.0076**	**0.0065**	0.0075	0.0063	
CS Fixed Effect BK			**-0.0084**	**-0.0053**	-0.0083	-0.0050	

Table C6. Panel Analysis for 5 Regions in Thailand with Quarterly Data, 2003-2015, Simple Model 7

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables				
	Simple7	Simple7 (Cont.)		Simple7 (Cont.)	
C	**0.0344** ***0.05***			d(UNEMP%)*DSR	**-0.0328** ***0.00***
d(logGASP)*DSR	**-0.3558** ***0.00***	d(logNATGASP) *DSR	**0.0668** ***0.10***	d(UNEMP%)*DNR	**0.0143** ***0.09***
d(logGASP)*DNR	**-0.3614** ***0.00***	d(logNATGASP) *DNR	**0.3850** ***0.00***	d(UNEMP%)*DCR	**0.0429** ***0.00***
d(logGASP)*DCR	**-0.0365** ***0.22***	d(logNATGASP) *DCR	**0.2423** ***0.00***	d(UNEMP%)*DNE	**0.0029** ***0.74***
d(logGASP)*DNE	**-0.1996** ***0.00***	d(logNATGASP) *DNE	**0.3823** ***0.00***	d(UNEMP%)*DBK	**0.0160** ***0.00***
d(logGASP)*DBK	**0.0634** ***0.09***	d(logNATGASP) *DBK	**-0.1041** ***0.06***	OILSHOCK*DSR	**-0.0117** ***0.04***
d(logGDP)*DSR	**0.8063** ***0.00***	d(logTRANSITP) *DSR	**0.0125** ***0.45***	OILSHOCK*DNR	**-0.0036** ***0.58***
d(logGDP)*DNR	**0.0848** ***0.71***	d(logTRANSITP) *DNR	**-0.0386** ***0.73***	OILSHOCK*DCR	**-0.0210** ***0.01***
d(logGDP)*DCR	**-0.8228** ***0.00***	d(logTRANSITP) *DCR	**0.5883** ***0.00***	OILSHOCK*DNE	**-0.0085** ***0.08***
d(logGDP)*DNE	**0.4454** ***0.08***	d(logTRANSITP) *DNE	**0.7184** ***0.00***	OILSHOCK*DBK	**-0.0098** ***0.12***
d(logGDP)*DBK	**0.1498** ***0.38***	d(logTRANSITP) *DBK	**-0.4852** ***0.00***	QUARTER1	**-0.0362** ***0.24***
d(logDIESELP) *DSR	**-0.0050** ***0.62***	d(NEWVEHQPC) *DSR	**49.6459** ***0.01***	QUARTER2	**-0.0226** ***0.11***
d(logDIESELP) *DNR	**0.0880** ***0.00***	d(NEWVEHQPC) *DNR	**-18.4756** ***0.41***	QUARTER3	**-0.0562** ***0.02***
d(logDIESELP) *DCR	**-0.1680** ***0.00***	d(NEWVEHQPC) *DCR	**43.0269** ***0.12***	Adjusted R-squared	**0.2518**
d(logDIESELP) *DNE	**-0.0984** ***0.02***	d(NEWVEHQPC) *DNE	**-14.7693** ***0.50***	F-Statistic	**2.6126** ***0.00***
d(logDIESELP) *DBK	**0.0097** ***0.65***	d(NEWVEHQPC) *DBK	**5.0614** ***0.18***	Durbin-Watson Stat	**2.5958**
d(logLPGP)*DSR	**-0.1754** ***0.00***	d(AGGDP%) *DSR	**-0.0158** ***0.00***	Akaike Info Criterion	**-2.9324**
d(logLPGP)*DNR	**-0.6921** ***0.00***	d(AGGDP%) *DNR	**0.0015** ***0.60***	Redundant Cross-section F-test	
d(logLPGP)*DCR	**-0.3275** ***0.00***	d(AGGDP%) *DCR	**0.0861** ***0.00***	CS Fixed Effect SR CS Fixed Effect NR	
d(logLPGP)*DNE	**-0.7699** ***0.00***	d(AGGDP%) *DNE	**-0.0101** ***0.01***	CS Fixed Effect CR CS Fixed Effect NE	
d(logLPGP)*DBK	**0.6275** ***0.00***	d(AGGDP%) *DBK	**-1.2812** ***0.00***	CS Fixed Effect BK	

Table C7. Panel Analysis for 5 Regions in Thailand with Quarterly Data, 2003-2015, Simple Model 8

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables				
	Simple8	Simple8 (Cont.)		Simple8 (Cont.)	
C	0.0342 *0.02*			d(UNEMP%)*DSR	-0.0326 *0.00*
d(logGASP)*DSR	-0.3541 *0.00*	d(logNATGASP) *DSR	0.0728 *0.03*	d(UNEMP%)*DNR	0.0148 *0.10*
d(logGASP)*DNR	-0.3666 *0.00*	d(logNATGASP) *DNR	0.3761 *0.00*	d(UNEMP%)*DCR	0.0467 *0.00*
d(logGASP)*DCR	-0.0362 *0.23*	d(logNATGASP) *DCR	0.2221 *0.00*	d(UNEMP%)*DNE	0.0030 *0.74*
d(logGASP)*DNE	-0.1931 *0.00*	d(logNATGASP) *DNE	0.3752 *0.00*	d(UNEMP%)*DBK	0.0173 *0.00*
d(logGASP)*DBK	0.0725 *0.06*	d(logNATGASP) *DBK	-0.0456 *0.30*	OILSHOCK*DSR	-0.0104 *0.00*
d(logGDP)*DSR	0.8559 *0.00*	d(logTRANSITP) *DSR	0.0159 *0.43*	OILSHOCK*DNR	-0.0093 *0.00*
d(logGDP)*DNR	-0.1099 *0.66*	d(logTRANSITP) *DNR	-0.0405 *0.73*	OILSHOCK*DCR	-0.0255 *0.00*
d(logGDP)*DCR	-0.8050 *0.00*	d(logTRANSITP) *DCR	0.5763 *0.00*	OILSHOCK*DNE	-0.0105 *0.00*
d(logGDP)*DNE	0.3001 *0.05*	d(logTRANSITP) *DNE	0.7262 *0.00*	OILSHOCK*DBK	0.0027 *0.46*
d(logGDP)*DBK	0.6501 *0.00*	d(logTRANSITP) *DBK	-0.5392 *0.00*	QUARTER1	-0.0366 *0.25*
d(logDIESELP) *DSR	-0.0078 *0.61*	d(NEWVEHQPC) *DSR	49.5056 *0.01*	QUARTER2	-0.0228 *0.10*
d(logDIESELP) *DNR	0.1010 *0.01*	d(NEWVEHQPC) *DNR	-17.5566 *0.44*	QUARTER3	-0.0560 *0.02*
d(logDIESELP) *DCR	-0.1583 *0.00*	d(NEWVEHQPC) *DCR	43.1340 *0.13*	Adjusted R-squared	0.2434
d(logDIESELP) *DNE	-0.1038 *0.00*	d(NEWVEHQPC) *DNE	-13.6703 *0.54*	F-Statistic	2.4334 *0.00*
d(logDIESELP) *DBK	-0.0097 *0.69*	d(NEWVEHQPC) *DBK	4.8105 *0.21*	Durbin-Watson Stat	2.6097
d(logLPGP)*DSR	-0.1774 *0.00*	d(AGGDP%) *DSR	-0.0152 *0.00*	Akaike Info Criterion	-2.9100
d(logLPGP)*DNR	-0.6783 *0.00*	d(AGGDP%) *DNR	-0.0039 *0.02*	Redundant Cross-section F-test	0.4427 *0.78*
d(logLPGP)*DCR	-0.3039 *0.00*	d(AGGDP%) *DCR	0.0791 *0.00*	CS Fixed Effect SR CS Fixed Effect NR	-0.0013 0.0068
d(logLPGP)*DNE	-0.7706 *0.00*	d(AGGDP%) *DNE	-0.0095 *0.01*	CS Fixed Effect CR CS Fixed Effect NE	0.0049 0.0036
d(logLPGP)*DBK	0.5577 *0.00*	d(AGGDP%) *DBK	0.8783 *0.01*	CS Fixed Effect BK	-0.0140

Table C8. Panel Analysis for 5 Regions in Thailand with Quarterly Data, 2003-2015, Simple Models 9 & 10, IV Model 1, and Asymmetric Models 1 & 2

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple9	Simple10	IV1	**Asym1**	**Asym2**		
C	0.0316 *0.02*	0.0318 *0.02*	0.0318 *0.03*	**0.0342** ***0.02***	**0.0351** ***0.01***		
d(log(GASP))	-0.1965 *0.01*	-0.1875 *0.01*	-0.2045 *0.00*				
d(log(GASPCUT))				**-0.1550** ***0.04***	**-0.1799** ***0.02***		
d(log(GASPREC))				**-0.2295** ***0.01***	**-0.2502** ***0.00***		
d(log(GDP))	-0.0240 *0.88*	-0.0898 *0.55*	-0.0368 *0.82*	**-0.0475** ***0.77***	**0.0180** ***0.92***		
d(log(DIESELP))		-0.0183 *0.70*	-0.0111 *0.90*	**-0.0270** ***0.61***	**-0.0068** ***0.92***		
d(log(DIESELP)) *DSR	-0.0809 *0.11*						
d(log(DIESELP)) *DNR	-0.0548 *0.29*						
d(log(DIESELP)) *DCR	-0.0372 *0.45*						
d(log(DIESELP)) *DNE	0.0213 *0.70*						
d(log(DIESELP)) *DBK	0.0671 *0.21*						
d(log(LPGP))	-0.2678 *0.30*		-0.2584 *0.35*	**-0.2562** ***0.32***	**-0.2485** ***0.34***		
d(log(LPGP)) *DSR		0.0856 *0.63*					
d(log(LPGP)) *DNR		-0.4803 *0.00*					
d(log(LPGP)) *DCR		-0.1532 *0.40*					
d(log(LPGP)) *DNE		-0.7334 *0.00*					
d(log(LPGP)) *DBK		0.1400 *0.42*					
d(log(NATGASP))	0.2066 *0.00*	0.1974 *0.00*	0.2000 *0.03*	**0.2139** ***0.00***	**0.1923** ***0.03***		
d(log(TRANSITP))	0.0848 *0.68*	0.0863 *0.67*	0.0970 *0.69*	**0.0973** ***0.63***	**0.0841** ***0.69***		
d(log(VEHP))							
d(NEWVEHQPC)	7.5740 *0.01*	7.0530 *0.01*	7.7523 *0.01*	**7.6625** ***0.01***	**5.2556** ***0.08***		
d(AGGDP%)	0.0041 *0.20*	0.0082 *0.03*	0.0042 *0.17*	**0.0042** ***0.20***	**0.0039** ***0.18***		
d(UNEMP%)	-0.0055 *0.63*	-0.0018 *0.88*	-0.0048 *0.66*	**-0.0054** ***0.64***	**-0.0079** ***0.45***		

Thailand d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple9	Simple10	IV1	**Asym1**	**Asym2**		
OILSHOCK	-0.0096 *0.12*	-0.0092 *0.13*	-0.0098 *0.14*	**-0.0096** ***0.10***	**-0.0110** ***0.02***		
QUARTER1	-0.0281 *0.30*	-0.0292 *0.29*	-0.0285 *0.31*	**-0.0293** ***0.28***	**-0.0256** ***0.33***		
QUARTER2	-0.0187 *0.15*	-0.0193 *0.13*	-0.0186 *0.24*	**-0.0188** ***0.14***	**-0.0203** ***0.07***		
QUARTER3	-0.0530 *0.02*	-0.0524 *0.02*	-0.0528 *0.03*	**-0.0534** ***0.02***	**-0.0552** ***0.01***		
FLOOD					**-0.1919** ***0.00***		
Adjusted R-squared	0.2182	0.2309	0.2236	**0.2218**	**0.2593**		
F-Statistic	4.3757 *0.00*	4.6315 *0.00*	5.0511 *0.00*	**5.0217** ***0.00***	**5.6797** ***0.00***		
DW-Stat	2.6830	2.6931	2.6697	**2.6751**	**2.5974**		
AIC	-2.9917	-3.0081		**-3.0071**	**-3.0529**		
Redundant Cross-section F-test	0.6381 *0.64*	0.7718 *0.54*		**0.6410** ***0.63***	**0.3839** ***0.82***		
CS Fixed Effect SR CS Fixed Effect NR CS Fixed Effect CR CS Fixed Effect NE CS Fixed Effect BK	-0.0020 0.0022 0.0009 0.0075 -0.0086	-0.0028 0.0022 0.0008 0.0086 -0.0088	-0.0021 0.0021 0.0008 0.0076 -0.0084	**-0.0021** **0.0021** **0.0008** **0.0076** **-0.0084**	**-0.0028** **0.0014** **0.0002** **0.0065** **-0.0053**		
Instrument Variable			log(OILP)				
Hausman Test for Endogeneity (resid)			*0.90*				
Wald Test (H0: GASPCUT =GASPREC)				***0.25***	***0.32***		

Table C9. Time Series Analysis for Southern Region with Annual Data, 2004-2015, Simple Models 1-3, IV Models 1-3, and Asymmetric Model 1

Southern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	IV1	IV2	IV3	Asym1
C	-0.0636 *0.32*	-0.0627 *0.32*	**-0.0435** ***0.12***	-0.0672 *0.31*	-0.0640 *0.34*	-0.0361 *0.78*	-0.1125 *0.28*
d(log(GASP))	-0.3865 *0.38*	-0.7118 *0.16*	**-0.5913** ***0.07***	-0.3061 *0.41*	-0.7594 *0.19*	-2.3186 *0.54*	
d(log(GASPCUT))							-0.2700 *0.53*
d(log(GASPREC))							0.8100 *0.46*
d(log(GDP))	0.1111 *0.93*	0.0844 *0.94*	**0.0520** ***0.95***	0.0898 *0.94*	0.1132 *0.93*	1.2394 *0.71*	-0.7011 *0.53*
d(log(DIESELP))	0.4505 *0.43*	0.4160 *0.45*	**0.5930** ***0.20***	0.3692 *0.52*	0.4499 *0.39*	2.7556 *0.55*	-0.1494 *0.61*
D(log(DIESELP)/ log(GASP))							
d(log(LPGP))	-0.4730 *0.45*			-0.5531 *0.41*			-0.6453 *0.44*
D(log(LPGP)/ log(GASP))		-1.5394 *0.44*			-1.6601 *0.41*		
d(log(NATGASP))	0.9171 *0.32*	0.8733 *0.31*	**0.5867** ***0.17***	0.9789 *0.31*	0.8909 *0.33*	0.3642 *0.82*	0.9696 *0.27*
d(log(TRANSITP))	-0.5086 *0.53*	-0.4407 *0.58*	**-0.7185** ***0.33***	-0.3778 *0.67*	-0.4985 *0.49*	-4.3196 *0.58*	0.3199 *0.46*
d(VEHQPC(-1))	4.6216 *0.42*	4.6193 *0.41*	**3.0680** ***0.25***	4.9569 *0.40*	4.6806 *0.43*	0.3388 *0.97*	9.2038 *0.28*
d(AGGDP%)	0.0370 *0.51*	0.0368 *0.51*	**0.0298** ***0.41***	0.0384 *0.50*	0.0373 *0.51*	0.0247 *0.74*	0.0241 *0.46*
d(UNEMP%)	0.2546 *0.44*	0.2373 *0.45*	**0.2162** ***0.32***	0.2531 *0.46*	0.2456 *0.42*	0.5179 *0.50*	0.1457 *0.41*
OILSHOCK	0.0787 *0.37*	0.0721 *0.39*	**0.0861** ***0.17***	0.0697 *0.49*	0.0775 *0.31*	0.3800 *0.54*	
Adjusted R-squared	0.8313	0.8372	**0.8684**	0.8250	0.8341	-1.6853	0.8775
Wald F-Statistic F-Statistic (for IV)	2694.33 *0.01*	3181.95 *0.01*	**4101.50** ***0.00***	6.1570 *0.30*	6.5816 *0.30*	0.4283 *0.85*	8.8829 *0.25*
DW-Stat	3.0232	3.0221	**2.6845**	2.8501	3.1244	2.4902	3.1288
AIC	-4.7954	-4.8311	**-4.5172**				-5.1158
Instrument Variable					log(OILP)		
Endogeneity Test				*0.32*	*0.32*	*0.34*	
Wald Test (H0: GASPCUT =GASPREC)							*0.40*

Table C10. Time Series Analysis for Southern Region with Annual Data, 2004-2015,
Asymmetric Models 1-8

Southern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym2	Asym3	Asym4	Asym5	Asym6	Asym7	Asym8
C	-0.1110 *0.28*	-0.0769 *0.14*	0.0444 *0.76*	-0.0072 *0.88*	-0.0079 *0.87*	-0.0155 *0.71*	-0.0150 *0.55*
d(log(GASP))							
d(log(GASPCUT))	-1.0631 *0.30*	-0.5021 *0.09*	-0.4018 *0.62*	-0.5643 *0.63*	-0.6669 *0.53*	-0.6380 *0.31*	-0.6150 *0.14*
d(log(GASPREC))	-0.0022 *0.99*	0.4575 *0.49*	0.4387 *0.87*	-0.6403 *0.38*	-0.7413 *0.30*	-0.8921 *0.42*	-0.7973 *0.04*
d(log(GDP))	-0.6930 *0.54*	-0.6926 *0.39*	1.4580 *0.36*	0.7814 *0.46*	0.7939 *0.44*	1.0458 *0.25*	0.9938 *0.10*
d(log(DIESELP))			-1.0008 *0.62*	-0.0944 *0.81*			
D(log(DIESELP)/ log(GASP))	-0.5149 *0.62*				-0.3941 *0.77*		
d(log(LPGP))			0.0927 *0.95*	0.0799 *0.96*	0.0564 *0.97*		
D(log(LPGP)/ log(GASP))	-0.6538 *0.44*					-0.3119 *0.91*	
d(log(NATGASP))	0.9740 *0.27*	0.4975 *0.07*	-0.2557 *0.90*	0.1969 *0.86*	0.2103 *0.85*	0.3558 *0.64*	0.2957 *0.23*
d(log(TRANSITP))	0.3194 *0.46*	0.1381 *0.45*	0.1641 *0.85*	0.4829 *0.29*	0.5071 *0.25*	0.3105 *0.49*	0.3103 *0.27*
d(VEHQPC(-1))	9.0849 *0.28*	6.5379 *0.14*					
d(log(VEHP(-1)))				-2.7472 *0.69*	-2.8238 *0.68*	-3.3901 *0.61*	-3.5108 *0.35*
d(NEWVEHQPC(-1))			-40.984 *0.68*				
d(AGGDP%)	0.0240 *0.46*	0.0136 *0.47*	-0.1757 *0.69*	-0.0042 *0.92*	-0.0048 *0.91*	0.0011 *0.97*	-0.0013 *0.93*
d(UNEMP%)	0.1443 *0.42*	0.0783 *0.37*	-0.7352 *0.67*	-0.0816 *0.75*	-0.0866 *0.73*	-0.0437 *0.84*	-0.0574 *0.58*
OILSHOCK						0.0370 *0.41*	0.0356 *0.20*
Adjusted R-squared	0.8769	0.9000	0.5017	0.4843	0.4936	0.6331	0.8141
Wald F-Statistic F-Statistic (for IV)	8.8391 *0.25*	13.3760 *0.03*	99251.1 *0.00*	17910.4 *0.01*	*179334* *0.00*	13496.1 *0.01*	8235.61 *0.00*
DW-Stat	3.1293	2.4385	1.7326	1.7185	1.7132	1.7849	1.8229
AIC	-5.1109	-4.5531	-3.7124	-3.6780	-3.6962	-4.0183	-4.1716
Wald Test (H0: GASPCUT =GASPREC)	*0.40*	*0.26*	*0.80*	*0.96*	*0.96*	*0.79*	*0.61*

Table C11. Time Series Analysis for Southern Region with Quarterly Data, 2003-2015, Simple Models 1-7

Southern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	Simple3	Simple4	**Simple5**	Simple6	**Simple7**
C	0.0075 *0.74*	0.0073 *0.75*	0.0069 *0.75*	0.0067 *0.76*	**0.0070** ***0.66***	0.0066 *0.68*	**0.0068** ***0.68***
d(log(GASP))	-0.3169 *0.01*	-0.3716 *0.01*	-0.3172 *0.00*	-0.3095 *0.00*	**-0.3100** ***0.00***	-0.3309 *0.01*	**-0.3145** ***0.13***
d(log(GDP))	1.0546 *0.05*	1.0161 *0.05*	0.9839 *0.04*	0.9787 *0.04*	**0.9773** ***0.03***	1.0144 *0.05*	**0.9795** ***0.05***
d(log(DIESELP))	-0.0070 *0.93*					0.0393 *0.69*	**0.0457** ***0.63***
D(log(DIESELP)/ log(GASP))		-0.0168 *0.95*					
d(log(LPGP))	-0.1346 *0.49*					-0.0390 *0.88*	
D(log(LPGP)/ log(GASP))		-0.2488 *0.73*					**0.0918** ***0.92***
d(log(NATGASP))	0.0465 *0.72*	0.0226 *0.86*	-0.0035 *0.97*			0.0470 *0.70*	**0.0231** ***0.85***
D(log(NATGASP)/ log(GASP))				0.0325 *0.93*	**0.0308** ***0.93***		
d(log(TRANSITP))	0.0677 *0.71*	0.0686 *0.72*	0.0733 *0.69*	0.0708 *0.69*	**0.0704** ***0.69***	0.0776 *0.64*	**0.0796** ***0.65***
d(log(VEHP(-3)))						-0.0164 *0.10*	**-0.0169** ***0.09***
d(NEWVEHQPC)	1.3398 *0.94*	0.9233 *0.96*	-0.3801 *0.98*	-0.5151 *0.98*			
d(AGGDP%)	-0.0056 *0.71*	-0.0042 *0.77*	-0.0030 *0.81*	-0.0031 *0.81*	**-0.0031** ***0.81***	-0.0025 *0.88*	**-0.0014** ***0.93***
d(UNEMP%)	-0.0381 *0.00*	-0.0378 *0.00*	-0.0376 *0.00*	-0.0377 *0.00*	**-0.0376** ***0.00***	-0.0389 *0.00*	**-0.0386** ***0.01***
QUARTER1	0.0368 *0.29*	0.0371 *0.28*	0.0375 *0.26*	0.0375 *0.26*	**0.0371** ***0.07***	0.0397 *0.06*	**0.0393** ***0.06***
QUARTER2	-0.0372 *0.12*	-0.0368 *0.13*	-0.0365 *0.11*	-0.0364 *0.11*	**-0.0365** ***0.08***	-0.0362 *0.10*	**-0.0360** ***0.10***
QUARTER3	-0.0266 *0.34*	-0.0265 *0.35*	-0.0259 *0.33*	-0.0256 *0.34*	**-0.0258** ***0.24***	-0.0220 *0.35*	**-0.0218** ***0.35***
OILSHOCK	-0.0090 *0.34*	-0.0092 *0.33*	-0.0093 *0.32*	-0.0090 *0.33*	**-0.0090** ***0.31***	-0.0084 *0.35*	**-0.0086** ***0.34***
Adjusted R-squared	0.5078	0.5063	0.5310	0.5311	**0.5428**	0.5307	**0.5306**
Wald F-Statistic F-Statistic (for IV)	18.6305 *0.00*	17.1930 *0.00*	13.2637 *0.00*	13.1718 *0.00*	**14.3897** ***0.00***	13.8875 *0.00*	**13.0689** ***0.00***
DW-Stat	2.4986	2.5034	2.5039	2.5110	**2.5070**	2.4232	**2.4159**
AIC	-3.5796	-3.5766	-3.6538	-3.6539	**-3.6931**	-3.6273	**-3.6271**

Table C12. Time Series Analysis for Southern Region with Quarterly Data, 2003-2015, IV Models 1-7

Southern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV1	IV2	IV3	IV4	IV5	IV6	IV7
C	0.0077 *0.73*	0.0071 *0.76*	0.0071 *0.76*	0.0069 *0.77*	0.0068 *0.76*	0.0071 *0.65*	0.0070 *0.66*
d(log(GASP))	-0.3008 *0.10*	-0.3090 *0.44*	-0.3102 *0.44*	-0.3044 *0.32*	-0.2896 *0.01*	-0.2896 *0.01*	-0.3080 *0.01*
d(log(GDP))	1.0548 *0.05*	0.9803 *0.07*	0.9810 *0.06*	0.9843 *0.07*	0.9713 *0.04*	0.9689 *0.03*	0.9765 *0.03*
d(log(DIESELP))	-0.0188 *0.89*						
D(log(DIESELP)/ log(GASP))		-0.0026 *0.99*					
d(log(LPGP))	-0.1375 *0.48*						
D(log(LPGP)/ log(GASP))		0.0156 *0.99*	0.0107 *0.99*	-0.0868 *0.95*			
d(log(NATGASP))	0.0529 *0.68*	-0.0028 *0.99*	-0.0026 *0.99*				
D(log(NATGASP)/ log(GASP))				0.1177 *0.79*	0.0936 *0.81*	0.0936 *0.81*	0.0368 *0.94*
d(log(TRANSITP))	0.0717 *0.71*	0.0718 *0.72*	0.0712 *0.71*	0.0624 *0.72*	0.0646 *0.71*	0.0638 *0.71*	0.0698 *0.70*
d(NEWVEHQPC)	1.0615 *0.96*	-0.5536 *0.98*	-0.5115 *0.98*	-0.3234 *0.99*	-0.7970 *0.97*		
d(AGGDP%)	-0.0056 *0.71*	-0.0029 *0.86*	-0.0029 *0.86*	-0.0036 *0.82*	-0.0031 *0.80*	-0.0033 *0.80*	-0.0032 *0.80*
d(UNEMP%)	-0.0381 *0.00*	-0.0374 *0.00*	-0.0374 *0.00*	-0.0375 *0.00*	-0.0374 *0.00*	-0.0373 *0.00*	-0.0376 *0.00*
QUARTER1	0.0365 *0.29*	0.0374 *0.28*	0.0374 *0.27*	0.0372 *0.27*	0.0373 *0.26*	0.0366 *0.06*	0.0370 *0.06*
QUARTER2	-0.0377 *0.11*	-0.0368 *0.13*	-0.0368 *0.12*	-0.0368 *0.12*	-0.0368 *0.11*	-0.0369 *0.07*	-0.0365 *0.08*
QUARTER3	-0.0269 *0.33*	-0.0260 *0.36*	-0.0260 *0.36*	-0.0256 *0.37*	-0.0255 *0.35*	-0.0258 *0.25*	-0.0258 *0.24*
OILSHOCK	-0.0092 *0.34*	-0.0094 *0.33*	-0.0094 *0.33*	-0.0087 *0.35*	-0.0087 *0.34*	-0.0088 *0.31*	-0.0090 *0.30*
Adjusted R-squared	0.5075	0.5055	0.5186	0.5189	0.5308	0.5425	0.5428
Wald F-Statistic F-Statistic (for IV)	4.6679 *0.00*	4.8097 *0.00*	5.3433 *0.00*‡	5.3020 *0.00*	5.8210 *0.00*	6.5551 *0.00*	6.6051 *0.00*
DW-Stat	2.4927	2.4971	2.4971	2.5091	2.5094	2.5029	2.5066
Instrument Variable	log(OILP)						log(DIE SELP)
Endogeneity Test	*0.91*	*0.90*	*0.92*	*0.91*	*0.89*	*0.88*	*0.99*

Table C13. Time Series Analysis for Southern Region with Quarterly Data, 2003-2015,
IV Models 8 & 9 and Asymmetric Models 1-5

Southern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV8	IV9	Asym1	Asym2	Asym3	Asym4	Asym5
C	0.0069 *0.66*	0.0072 *0.65*	0.0061 *0.80*	0.0061 *0.80*	0.0058 *0.81*	0.0076 *0.68*	0.0079 *0.67*
d(log(GASP))	-0.3217 *0.09*	-0.2651 *0.62*					
d(logGASPCUT)			-0.3434 *0.03*	-0.3936 *0.03*	-0.3264 *0.01*	-0.3162 *0.08*	-0.2936 *0.25*
d(logGASPREC)			-0.2949 *0.03*	-0.3529 *0.04*	-0.2931 *0.03*	-0.3449 *0.01*	-0.3266 *0.11*
d(log(GDP))	1.0147 *0.05*	0.9508 *0.07*	1.0827 *0.06*	1.0381 *0.07*	0.9933 *0.04*	0.9965 *0.07*	0.9612 *0.07*
d(log(DIESELP))	0.0325 *0.83*	0.0414 *0.73*	-0.0014 *0.99*			0.0379 *0.72*	0.0435 *0.67*
D(log(DIESELP)/ log(GASP))				-0.0012 *0.99*			
d(log(LPGP))	-0.0421 *0.87*		-0.1454 *0.47*			-0.0316 *0.90*	
D(log(LPGP)/ log(GASP))		0.2808 *0.88*		-0.2710 *0.71*			0.1099 *0.90*
d(log(NATGASP))	0.0508 *0.68*	0.0074 *0.97*	0.0416 *0.75*	0.0174 *0.89*		0.0505 *0.69*	0.0284 *0.82*
D(log(NATGASP)/ log(GASP))					0.0180 *0.96*		
d(log(TRANSITP))	0.0796 *0.65*	0.0856 *0.67*	0.0715 *0.70*	0.0719 *0.71*	0.0761 *0.68*	0.0750 *0.67*	0.0769 *0.68*
d(log(VEHP(-3)))	-0.0163 *0.10*	-0.0172 *0.10*				-0.0170 *0.05*	-0.0175 *0.04*
d(NEWVEHQPC)			1.9992 *0.92*	1.4578 *0.94*	-0.2325 *0.99*		
d(AGGDP%)	-0.0025 *0.88*	-0.0006 *0.97*	-0.0061 *0.69*	-0.0045 *0.76*	-0.0032 *0.80*	-0.0022 *0.89*	-0.0012 *0.94*
d(UNEMP%)	-0.0389 *0.00*	-0.0383 *0.01*	-0.0374 *0.00*	-0.0372 *0.00*	-0.0372 *0.00*	-0.0393 *0.00*	-0.0391 *0.00*
QUARTER1	0.0394 *0.06*	0.0383 *0.07*	0.0368 *0.30*	0.0372 *0.29*	0.0376 *0.27*	0.0394 *0.07*	0.0390 *0.07*
QUARTER2	-0.0366 *0.09*	-0.0364 *0.09*	-0.0374 *0.12*	-0.0370 *0.13*	-0.0365 *0.12*	-0.0362 *0.10*	-0.0360 *0.10*
QUARTER3	-0.0223 *0.34*	-0.0220 *0.35*	-0.0265 *0.35*	-0.0264 *0.36*	-0.0255 *0.35*	-0.0220 *0.35*	-0.0219 *0.36*
OILSHOCK	-0.0085 *0.35*	-0.0089 *0.35*	-0.0093 *0.35*	-0.0094 *0.34*	-0.0092 *0.34*	-0.0083 *0.37*	-0.0084 *0.36*
Adjusted R-squared	0.5306	0.5301	0.4951	0.4932	0.5192	0.5180	0.5180
Wald F-Statistic F-Statistic (for IV)	5.0127 *0.00*	5.2268 *0.00*	18.2535 *0.00*‡	16.3575 *0.00*	12.1978 *0.00*	14.0040 *0.00*	13.2264 *0.00*
DW-Stat	2.4172	2.3977	2.4896	2.4963	2.5064	2.4182	2.4097

Southern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV8	IV9	Asym1	Asym2	Asym3	Asym4	Asym5
AIC			-3.5424	-3.5387	-3.6156	-3.5888	-3.5888
Instrument Variable	log(OILP)						
Endogeneity Test	*0.95*	*0.94*					
Wald Test (H0: GASPCUT =GASPREC)			*0.78*	*0.82*	*0.83*	*0.87*	*0.85*

Table C14. Time Series Analysis for Northern Region with Annual Data, 2004-2015, Simple Models 1-3 and IV Models 1-4

Northern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	IV1	IV2	IV3	IV4
C	0.0149 *0.25*	0.0120 *0.22*	**0.0318** ***0.02***	0.0124 *0.43*	0.0136 *0.34*	0.0333 *0.01*	0.0357 *0.04*
d(log(GASP))	-0.2493 *0.04*	-0.5828 *0.03*	**-0.3889** ***0.00***	-0.2189 *0.31*	-0.5609 *0.10*	-0.4378 *0.01*	-0.5142 *0.03*
d(log(GDP))	-0.4458 *0.18*	-0.3840 *0.16*	**-0.4864** ***0.12***	-0.4675 *0.23*	-0.4090 *0.26*	-0.3906 *0.15*	-0.2411 *0.35*
d(log(DIESELP))	-0.1183 *0.12*			-0.1316 *0.30*			
D(log(DIESELP)/ log(GASP))		-0.3800 *0.12*			-0.3697 *0.13*		
d(log(LPGP))	-0.2643 *0.19*			-0.2970 *0.22*			
D(log(LPGP)/ log(GASP))		-1.0114 *0.11*			-0.9123 *0.27*		
d(log(NATGASP))	0.5060 *0.05*	0.4990 *0.04*	**0.3551** ***0.04***	0.5412 *0.15*	0.4942 *0.05*	0.2957 *0.03*	0.2031 *0.06*
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	-0.0526 *0.53*	-0.0883 *0.38*	**-0.0547** ***0.68***	-0.0675 *0.59*	-0.0791 *0.35*	-0.0079 *0.97*	0.0651 *0.83*
d(VEHQPC(-1))	1.7346 *0.15*	1.8406 *0.12*	**1.0712** ***0.14***	1.9146 *0.23*	1.7923 *0.14*	0.7325 *0.13*	0.2042 *0.72*
d(AGGDP%)	-0.0078 *0.29*	-0.0066 *0.29*	**-0.0153** ***0.05***	-0.0070 *0.41*	-0.0075 *0.36*	-0.0150 *0.07*	-0.0144 *0.22*
d(UNEMP%)	-0.1393 *0.10*	-0.1443 *0.08*	**-0.1343** ***0.03***	-0.1424 *0.15*	-0.1451 *0.10*	-0.1252 *0.02*	-0.1110 *0.02*
OILSHOCK	-0.0089 *0.40*	-0.0068 *0.35*	**-0.0241** ***0.11***	-0.0066 *0.59*	-0.0085 *0.50*	-0.0253 *0.22*	-0.0272 *0.41*
Adjusted R-squared	0.9754	0.9829	**0.9426**	0.9717	0.9818	0.9355	0.8962
Wald F-Statistic F-Statistic (for IV)	1946.46 *0.02*	7782.46 *0.01*	**2239.72** ***0.00***	38.4501 *0.12*	59.7370 *0.00*	20.4861 *0.02*	12.4358 *0.03*
DW-Stat	2.6383	2.5629	**3.0494**	2.4988	2.8376	2.4547	1.5195
AIC	-7.1547	-7.5143#	**-5.5403**				
Instrument Variable				log(OILP)			log(DIE SELP)
Endogeneity Test				*0.32*	*0.32*	*0.42*	*0.24*

Table C15. Time Series Analysis for Northern Region with Annual Data, 2004-2015, Asymmetric Models 1-3

Northern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym1	Asym2	Asym3				
C	0.0193 *0.33*	0.0159 *0.31*	0.0217 *0.52*				
d(log(GASP))							
d(log(GASPCUT))	-0.1408 *0.35*	-0.5261 *0.10*	-0.5556 *0.37*				
d(log(GASPREC))	-0.3260 *0.15*	-0.6778 *0.06*	-0.2275 *0.67*				
d(log(GDP))	-0.5601 *0.24*	-0.4753 *0.23*	-0.2722 *0.73*				
d(log(DIESELP))	-0.1242 *0.11*						
D(log(DIESELP)/ log(GASP))		-0.3936 *0.11*					
d(log(LPGP))	-0.3141 *0.14*						
D(log(LPGP)/ log(GASP))		-1.1268 *0.10*					
d(log(NATGASP))	0.6149 *0.09*	0.5829 *0.08*	0.2042 *0.68*				
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	-0.1510 *0.24*	-0.1661 *0.17*	0.1054 *0.87*				
d(VEHQPC(-1))	1.3575 *0.31*	1.5159 *0.23*	1.9467 *0.56*				
d(AGGDP%)	-0.0046 *0.28*	-0.0041 *0.26*	-0.0197 *0.38*				
d(UNEMP%)	-0.1702 *0.16*	-0.1704 *0.13*	-0.0757 *0.74*				
OILSHOCK			-0.0381 0.52				
Adjusted R-squared	0.9871	0.9916	0.9269				
Wald F-Statistic F-Statistic (for IV)	6581.28 *0.01*	13010.9 *0.01*	299.898 *0.00*				
DW-Stat	2.9530	2.9338	3.0521				
AIC	-7.7987	-8.2259	-5.5374				
Wald Test (H0: GASPCUT =GASPREC)	*0.46*	*0.46*	*0.76*				

Table C16. Time Series Analysis for Northern Region with Quarterly Data, 2003-2015, Simple Models 1-7

Northern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	Simple3	**Simple4**	Simple5	Simple6	**Simple7**
C	0.0676 *0.01*	0.0679 *0.01*	0.0685 *0.02*	**0.0603** ***0.01***	0.0629 *0.01*	0.0624 *0.01*	**0.0645** ***0.01***
d(log(GASP))	-0.3762 *0.08*	-0.8256 *0.00*	-0.4076 *0.09*	**-0.3958** ***0.09***	-0.3323 *0.11*	-0.7207 *0.00*	**-0.3575** ***0.11***
d(log(GDP))	-0.2729 *0.62*	-0.2313 *0.67*	-0.3318 *0.61*	**-0.3251** ***0.62***	-0.4228 *0.42*	-0.3889 *0.46*	**-0.4906** ***0.43***
d(log(DIESELP))	0.1146 *0.64*	0.1380 *0.57*	0.1803 *0.49*	**0.1705** ***0.49***	0.1574 *0.52*	0.1788 *0.46*	**0.2211** ***0.38***
D(log(DIESELP)/ log(GASP))							
d(log(LPGP))	-0.6612 *0.00*				-0.5891 *0.01*		
D(log(LPGP)/ log(GASP))		-2.0837 *0.01*				-1.8036 *0.02*	
d(log(NATGASP))	0.3025 *0.18*	0.2557 *0.24*	0.0273 *0.88*	**0.0464** ***0.80***	0.2899 *0.17*	0.2443 *0.22*	**0.0433** ***0.78***
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	-0.0771 *0.87*	-0.1017 *0.83*	-0.0710 *0.88*	**-0.0517** ***0.91***	0.0173 *0.97*	-0.0013 *0.99*	**0.0289** ***0.95***
d(log(VEHP(-3)))					-0.0469 *0.09*	-0.0473 *0.08*	**-0.0516** ***0.06***
d(NEWVEHQPC (-3))	-12.652 *0.55*	-14.014 *0.51*	-11.896 *0.57*				
d(AGGDP%)	-0.0042 *0.67*	-0.0035 *0.73*	-0.0041 *0.77*	**-0.0040** ***0.78***	-0.0054 *0.57*	-0.0049 *0.64*	**-0.0055** ***0.69***
d(UNEMP%)	0.0075 *0.85*	0.0094 *0.82*	0.0082 *0.84*	**0.0092** ***0.82***	0.0149 *0.71*	0.0167 *0.68*	**0.0161** ***0.69***
QUARTER1	-0.0740 *0.06*	-0.0728 *0.07*	-0.0771 *0.07*	**-0.0692** ***0.08***	-0.0634 *0.10*	-0.0617 *0.11*	**-0.0664** ***0.09***
QUARTER2	-0.0410 *0.17*	-0.0409 *0.18*	-0.0363 *0.28*	**-0.0269** ***0.40***	-0.0308 *0.32*	-0.0296 *0.34*	**-0.0271** ***0.39***
QUARTER3	-0.0980 *0.00*	-0.0997 *0.00*	-0.0964 *0.01*	**-0.0839** ***0.00***	-0.0743 *0.00*	-0.0744 *0.00*	**-0.0726** ***0.00***
OILSHOCK	-0.0116 *0.34*	-0.0119 *0.33*	-0.0147 *0.17*	**-0.0144** ***0.17***	-0.0147 *0.22*	-0.0151 *0.21*	**-0.0178** ***0.11***
Adjusted R-squared	0.3933	0.3864	0.3699	**0.3839**	0.4283	0.4215	**0.4125**
Wald F-Statistic F-Statistic (for IV)	11.7186 *0.00*	11.2774 *0.00*	10.2497 *0.00*	**12.0952** ***0.00***	13.6378 *0.00*	13.4145 *0.00*	**15.6453** ***0.00***
DW-Stat	2.4134	2.4015	2.2895	**2.2942**	2.4230	2.4025	**2.3023**
AIC	-2.8377	-2.8264	2.8124	**-2.8480**	-2.8971	-2.8852	**-2.8823**

Table C17. Time Series Analysis for Northern Region with Quarterly Data, 2003-2015, IV Models 1-7

Northern Region (log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV1	IV2	IV3	IV4	IV5	IV6	IV7
C	0.0687 *0.01*	0.0706 *0.01*	0.0629 *0.00*	0.0630 *0.01*	0.0694 *0.00*	0.0696 *0.00*	0.0691 *0.00*
d(log(GASP))	-0.1323 *0.57*	-0.1709 *0.73*	-0.1908 *0.70*	-0.1727 *0.24*	-0.0524 *0.81*	0.1198 *0.84*	0.2228 *0.64*
d(log(GDP))	-0.3988 *0.49*	-0.3859 *0.57*	-0.3729 *0.58*	-0.3770 *0.57*	-0.5886 *0.29*	-0.6271 *0.39*	-0.8488 *0.24*
d(log(DIESELP))	-0.0871 *0.75*				-0.0663 *0.82*		
D(log(DIESELP)/ log(GASP))		0.6934 *0.50*	0.6529 *0.51*	0.6596 *0.48*		0.8993 *0.40*	0.7200 *0.51*
d(log(LPGP))	-0.7137 *0.00*				-0.6448 *0.01*		
D(log(LPGP)/ log(GASP))		0.0049 *0.99*	-0.0808 *0.97*			0.8001 *0.74*	0.2681 *0.90*
d(log(NATGASP))	0.3981 *0.05*	0.0412 *0.89*	0.0674 *0.82*	0.0584 *0.73*	0.3872 *0.03*	-0.0291 *0.93*	
D(log(NATGASP)/ log(GASP))							0.9366 *0.18*
d(log(TRANSITP))	0.1525 *0.77*	-0.1815 *0.73*	-0.1594 *0.75*	-0.1592 *0.75*	0.2802 *0.61*	-0.0647 *0.91*	-0.0669 *0.91*
d(log(VEHP(-3)))					-0.0516 *0.04*	-0.0603 *0.03*	-0.0611 *0.03*
d(NEWVEHQPC (-3))	-6.5566 *0.76*	-10.797 *0.61*					
d(AGGDP%)	-0.0021 *0.82*	-0.0033 *0.82*	-0.0032 *0.82*	-0.0032 *0.82*	-0.0033 *0.73*	-0.0049 *0.77*	-0.0103 *0.44*
d(UNEMP%)	0.0151 *0.71*	0.0115 *0.78*	0.0123 *0.76*	0.0122 *0.75*	0.0238 *0.54*	0.0207 *0.60*	0.0201 *0.61*
QUARTER1	-0.0797 *0.05*	-0.0807 *0.05*	-0.0730 *0.06*	-0.0733 *0.06*	-0.0745 *0.05*	-0.0735 *0.04*	-0.0770 *0.03*
QUARTER2	-0.0450 *0.13*	-0.0385 *0.26*	-0.0300 *0.35*	-0.0299 *0.33*	-0.0409 *0.18*	-0.0301 *0.36*	-0.0300 *0.33*
QUARTER3	-0.0959 *0.00*	-0.0960 *0.01*	-0.0847 *0.00*	-0.0846 *0.00*	-0.0782 *0.00*	-0.0713 *0.00*	-0.0677 *0.00*
OILSHOCK	-0.0135 *0.30*	-0.0145 *0.18*	-0.0141 *0.18*	-0.0142 *0.18*	-0.0175 *0.19*	-0.0193 *0.09*	-0.0160 *0.20*
Adjusted R-squared	0.3684	0.3479	0.3659	0.3797	0.3950	0.3591	0.3554
Wald F-Statistic F-Statistic (for IV)	3.1000 *0.00*	2.9302 *0.01*	3.2580 *0.00*	3.6132 *0.00*	3.4492 *0.00*	3.2430 *0.00*	3.3074 *0.00*
DW-Stat	2.4047	2.2879	2.2991	2.2930	2.3757	2.2018	2.3215
Instrument Variable	log(OILP)						
Endogeneity Test	*0.36*	*0.37*	*0.40*	*0.34*	*0.29*	*0.29*	*0.27*

Table C18. Time Series Analysis for Northern Region with Quarterly Data, 2003-2015, Asymmetric Models 1-7

Northern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym1	Asym2	Asym3	Asym4	Asym5	Asym6	**Asym7**
C	0.0743 *0.02*	0.0748 *0.02*	0.0757 *0.02*	0.0661 *0.01*	0.0775 *0.00*	0.0773 *0.00*	**0.0800** ***0.00***
d(log(GASPCUT))	-0.2908 *0.28*	-0.7333 *0.00*	-0.3164 *0.26*	-0.3062 *0.27*	-0.1205 *0.65*	-0.4675 *0.04*	**-0.1282** ***0.64***
d(log(GASPREC))	-0.5089 *0.02*	-0.9587 *0.00*	-0.5481 *0.02*	-0.5297 *0.02*	-0.6122 *0.01*	-0.9676 *0.00*	**-0.6544** ***0.01***
d(log(GDP))	-0.2061 *0.71*	-0.1622 *0.77*	-0.2598 *0.69*	-0.2548 *0.70*	-0.3490 *0.51*	-0.3169 *0.54*	**-0.4044** ***0.51***
d(log(DIESELP))	0.1161 *0.64*	0.1389 *0.57*	0.1808 *0.49*	0.1695 *0.50*	0.1844 *0.42*	0.2039 *0.37*	**0.2432** ***0.31***
d(log(LPGP))	-0.6510 *0.00*				-0.5306 *0.03*		
D(log(LPGP)/ log(GASP))		-2.0655 *0.01*				-1.6286 *0.06*	
d(log(NATGASP))	0.3281 *0.21*	0.2845 *0.26*	0.0589 *0.76*	*0.0796* *0.68*	0.3371 *0.19*	0.2977 *0.23*	**0.1201** ***0.49***
d(log(TRANSITP))	-0.1638 *0.70*	-0.1912 *0.66*	-0.1633 *0.69*	-0.1380 *0.73*	-0.1351 *0.72*	-0.1546 *0.68*	**-0.1355** ***0.72***
d(log(VEHP(-3)))					-0.0705 *0.00*	-0.0713 *0.00*	**-0.0764** ***0.00***
d(NEWVEHQPC (-3))	-14.289 *0.53*	-15.700 *0.50*	-13.648 *0.55*				
d(AGGDP%)	-0.0052 *0.62*	-0.0046 *0.68*	-0.0052 *0.72*	-0.0050 *0.73*	-0.0083 *0.45*	-0.0079 *0.50*	**-0.0086** ***0.55***
d(UNEMP%)	-0.0008 *0.98*	0.0007 *0.98*	-0.0007 *0.99*	0.0008 *0.98*	-0.0005 *0.99*	0.0009 *0.98*	**-0.0005** ***0.99***
QUARTER1	-0.0738 *0.07*	-0.0726 *0.07*	-0.0769 *0.07*	-0.0678 *0.08*	-0.0594 *0.11*	-0.0577 *0.12*	**-0.0618** ***0.10***
QUARTER2	-0.0406 *0.19*	-0.0405 *0.20*	-0.0360 *0.30*	-0.0253 *0.41*	-0.0269 *0.36*	-0.0258 *0.38*	**-0.0234** ***0.43***
QUARTER3	-0.1019 *0.01*	-0.1037 *0.01*	-0.1006 *0.01*	-0.0862 *0.00*	-0.0740 *0.00*	-0.0740 *0.00*	**-0.0724** ***0.00***
OILSHOCK	-0.0103 *0.39*	-0.0106 *0.38*	-0.0133 *0.21*	-0.0130 *0.21*	-0.0134 *0.27*	-0.0137 *0.26*	**-0.0161** ***0.18***
Adjusted R-squared	0.3864	0.3801	0.3639	0.3776	0.4537	0.4481	**0.4429**
Wald F-Statistic F-Statistic (for IV)	12.4279 *0.00*	11.4788 *0.00*	8.9905 *0.00*	10.5790 *0.00*	43.4154 *0.00*	45.9085 *0.00*	**53.4749** ***0.00***
DW-Stat	2.4472	2.4384	2.3130	2.3200	2.4649	2.4448	**2.3204**
AIC	-2.8146	-2.8043	-2.7903	-2.8247	-2.9306	-2.9206	**-2.9229**
Wald Test (H0: GASPCUT =GASPREC)	*0.37*	*0.36*	*0.33*	*0.33*	*0.06*	*0.06*	***0.04***

Table C19. Time Series Analysis for Central Region with Annual Data, 2004-2015,
Simple Models 1-3 and IV Models 1-4

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	IV1	IV2	IV3	IV4
C	0.1384 *0.21*	0.1326 *0.14*	**0.0490** ***0.21***	0.1466 *0.19*	0.1155 *0.19*‡	0.0508 *0.29*	0.0426 *0.47*
d(log(GASP))	0.0912 *0.58*	-0.9004 *0.13*	**-0.1349** ***0.13***	0.1290 *0.31*	-0.7292 *0.37*	-0.1216 *0.38*	-0.1802 *0.44*
d(log(GDP))	1.2774 *0.34*	1.2967 *0.20*	**-0.2630** ***0.30***	1.4223 *0.25*	0.9778 *0.49*	-0.2471 *0.42*	-0.3171 *0.47*
d(log(DIESELP))	-0.0492 *0.49*			-0.0635 *0.45*			
D(log(DIESELP)/ log(GASP))		-0.1555 *0.37*			-0.1453 *0.70*		
d(log(LPGP))	-1.2610 *0.29*			-1.3623 *0.22*			
D(log(LPGP)/ log(GASP))		-4.2328 *0.17*			-3.3286 *0.42*		
d(log(NATGASP))	1.3177 *0.24*	1.2555 *0.13*	**0.3393** ***0.11***	1.4133 *0.16*	1.0723 *0.33*	0.3550 *0.14*	0.2862 *0.28*
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	-0.6639 *0.25*	-0.6818 *0.16*	**-0.1066** ***0.32***	-0.6998 *0.25*	-0.5535 *0.32*	-0.1111 *0.33*	-0.0913 *0.53*
d(log(VEHP))							
d(VEHQPC)	-11.766 *0.32*	-11.015 *0.21*	**0.2575** ***0.93***	-12.866 *0.26*	-8.7050 *0.40*	0.0622 *0.99*	0.9222 *0.85*
d(AGGDP%)	-0.2068 *0.28*	-0.2041 *0.17*	**-0.0140** ***0.77***	-0.2261 *0.22*	-0.1662 *0.36*	-0.0178 *0.79*	-0.0008 *0.99*
d(UNEMP%)	0.2341 *0.26*	0.1987 *0.18*	**0.0249** ***0.68***	0.2528 *0.25*	0.1632 *0.29*	0.0285 *0.71*	0.0128 *0.91*
OILSHOCK	-0.0830 *0.15*	-0.0801 *0.10*	**-0.0519** ***0.15***	-0.0871 *0.14*	-0.0752 *0.11*	-0.0535 *0.22*	-0.0463 *0.30*
Adjusted R-squared	0.9377	0.9716	**0.8706**	0.9328	0.9549	0.8700	0.8637
Wald F-Statistic F-Statistic (for IV)	61495.4 *0.00*	13756.6 *0.01*	**466.459** ***0.00***	16.3146 *0.19*	23.7075 *0.16*	10.1355 *0.04*	9.6904 *0.04*
DW-Stat	2.7461	2.8900	**1.9135**	3.1766	2.3586	1.9760	1.6765
AIC	-5.9473	-6.7316	**-4.4509**				
Instrument Variable				Log(OILP)			Log(DIE SELP)
Endogeneity Test				*0.32*	*0.32*	*0.84*	*0.73*

Table C20. Time Series Analysis for Central Region with Annual Data, 2004-2015, Asymmetric Models 1-3

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym1	Asym2	Asym3				
C	0.0415 *0.81*	0.0405 *0.81*	0.0480 *0.33*		#		
d(log(GASPCUT))	-0.2043 *0.65*	-1.3655 *0.48*	-0.0644 *0.79*				
d(log(GASPREC))	1.4731 *0.78*	0.5911 *0.89*	-0.3676 *0.64*				
d(log(GDP))	2.3619 *0.74*	2.7915 *0.64*	-0.5651 *0.63*				
d(log(DIESELP))	-0.4087 *0.77*						
D(log(DIESELP)/ log(GASP))		-1.6307 *0.75*					
d(log(LPGP))	-0.8203 *0.73*						
D(log(LPGP)/ log(GASP))		-3.1780 *0.61*					
d(log(NATGASP))	0.7863 *0.64*	0.8310 *0.51*	0.3604 *0.25*				
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	-1.5349 *0.64*	-1.7138 *0.46*	0.1223 *0.87*				
d(log(VEHP))							
d(VEHQPC)	-4.6558 *0.82*	-5.2204 *0.65*	0.9342 *0.84*				
d(NEWVEHQPC (-1))							
d(AGGDP%)	-0.2693 *0.73*	-0.3146 *0.61*	0.0212 *0.89*				
d(UNEMP%)	0.4608 *0.68*	0.5012 *0.56*	-0.0400 *0.88*				
OILSHOCK			-0.0536 *0.20*				
Adjusted R-squared	0.4537	0.5224	0.8199				
Wald F-Statistic F-Statistic (for IV)	135.279 *0.07*	56.3118 *0.10*	1662.58 *0.00*				
DW-Stat	2.0240	2.2718	1.6211				
AIC	-3.7758	-3.9101	-4.3591				
Wald Test (H0: GASPCUT =GASPREC)	*0.76*	*0.73*	*0.76*				

Table C21. Time Series Analysis for Central Region with Quarterly Data, 2003-2015, Simple Models 1-7

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	Simple3	**Simple4**	Simple5	Simple6	**Simple7**
C	0.0518 *0.00*	0.0530 *0.00*	0.0538 *0.00*	**0.0444** ***0.01***	0.0461 *0.00*	0.0472 *0.00*	**0.0471** ***0.00***
d(log(GASP))	0.0180 *0.89*	-0.2368 *0.24*	-0.1148 *0.42*	**-0.1069** ***0.45***	0.0396 *0.76*	-0.1153 *0.56*	**-0.0428** ***0.58***
d(log(GDP))	-0.6743 *0.06*	-0.7155 *0.04*	-0.8842 *0.03*	**-0.8788** ***0.04***	-0.6991 *0.05*	-0.7327 *0.03*	**-0.8526** ***0.03***
d(log(DIESELP))	-0.1859 *0.11*				-0.1130 *0.32*		
D(log(DIESELP)/ log(GASP))		-0.6012 *0.16*				-0.3871 *0.36*	
d(log(LPGP))	-0.2746 *0.17*				-0.2315 *0.26*		
D(log(LPGP)/ log(GASP))		-0.3917 *0.65*				-0.2533 *0.77*	
d(log(NATGASP))	0.1372 *0.34*	0.0682 *0.57*			0.1366 *0.31*	0.0707 *0.58*	**0.0212** ***0.85***
D(log(NATGASP)/ log(GASP))			0.0693 *0.90*	**0.1017** ***0.85***			
d(log(TRANSITP))	0.7380 *0.04*	0.7880 *0.04*	0.5594 *0.05*	**0.5704** ***0.05***	0.6945 *0.07*	0.7547 *0.06*	**0.6245** ***0.05***
d(log(VEHP(-3)))					-0.0493 *0.03*	-0.0500 *0.02*	**-0.0533** ***0.01***
d(NEWVEHQPC (-3))	-15.859 *0.40*	-16.390 *0.39*	-19.085 *0.29*				
d(AGGDP%)	0.0770 *0.02*	0.0779 *0.03*	0.0860 *0.04*	**0.0861** ***0.05***	0.0686 *0.04*	0.0691 *0.06*	**0.0758** ***0.06***
d(UNEMP%)	0.0438 *0.44*	0.0476 *0.41*	0.0470 *0.39*	**0.0461** ***0.39***	0.0431 *0.45*	0.0470 *0.42*	**0.0462** ***0.40***
QUARTER1	-0.0165 *0.41*	-0.0178 *0.38*	-0.0196 *0.35*	**-0.0092** ***0.67***	-0.0008 *0.96*	-0.0019 *0.91*	**-0.0013** ***0.95***
QUARTER2	-0.0521 *0.02*	-0.0525 *0.03*	-0.0509 *0.03*	**-0.0407** ***0.07***	-0.0407 *0.06*	-0.0411 *0.06*	**-0.0391** ***0.08***
QUARTER3	-0.0884 *0.00*	-0.0897 *0.00*	-0.0883 *0.00*	**-0.0741** ***0.00***	-0.0670 *0.00*	-0.0677 *0.00*	**-0.0654** ***0.00***
OILSHOCK	-0.0318 0.02	-0.0332 0.01	-0.0304 0.02	**-0.0305** ***0.02***	-0.0340 *0.01*	-0.0356 *0.00*	**-0.0345** ***0.00***
Adjusted R-squared	0.4544	0.4473	0.4549	**0.4625**	0.5289	0.5251	**0.5411**
Wald F-Statistic F-Statistic (for IV)	16.9855 *0.00*	15.4262 *0.00*	10.2282 *0.00*	**10.5420** ***0.00***	14.4610 *0.00*	12.4547 *0.00*	**16.7679** ***0.00***
DW-Stat	2.4323	2.4079	2.4456	**2.4571**	2.2812	2.2343	**2.2104**
AIC	-3.3421	-3.3291	-3.3688	**-3.3966**	-3.4889	-3.4807	**-3.5408**

Table C22. Time Series Analysis for Central Region with Quarterly Data, 2003-2015, IV Models 1-7

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV1	IV2	IV3	IV4	IV5	IV6	IV7
C	0.0522 *0.00*	0.0542 *0.00*	0.0531 *0.01*	0.0448 *0.00*	0.0424 *0.00*	0.0468 *0.00*	0.0489 *0.00*
d(log(GASP))	0.0359 *0.89*	-0.1642 *0.78*	-0.1835 *0.21*	-0.1657 *0.02*	-0.1994 *0.00*	0.0642 *0.83*	0.0020 *0.99*
d(log(GDP))	-0.6569 *0.08*	-0.7377 *0.08*	-0.9366 *0.02*	-0.5219 *0.23*	-0.5056 *0.25*	-0.6755 *0.08*	-0.7682 *0.08*
d(log(DIESELP))	-0.1992 *0.39*					-0.1309 *0.60*	
D(log(DIESELP)/ log(GASP))		-0.5839 *0.15*					-0.3532 *0.35*
d(log(LPGP))	-0.2755 *0.17*					-0.2325 *0.26*	
D(log(LPGP)/ log(GASP))		-0.0986 *0.97*					0.2096 *0.94*
d(log(NATGASP))	0.1434 *0.25*	0.0369 *0.91*				0.1449 *0.30*	0.0218 *0.95*
D(log(NATGASP)/ log(GASP))			-0.1365 *0.78*				
d(log(TRANSITP))	0.7480 *0.07*	0.8006 *0.05*	0.6172 *0.05*	0.5255 *0.06*	0.5523 *0.05*	0.7077 *0.10*	0.7732 *0.07*
d(log(VEHP(-3)))						-0.0494 *0.03*	-0.0516 *0.02*
d(NEWVEHQPC (-3))	-15.604 *0.42*	-16.592 *0.38*	-19.901 *0.30*				
d(AGGDP%)	0.0755 *0.03*	0.0783 *0.04*	0.0939 *0.02*	0.0430 *0.26*	0.0421 *0.28*	0.0665 *0.06*	0.0694 *0.08*
d(UNEMP%)	0.0455 *0.43*	0.0509 *0.38*	0.0413 *0.44*	0.0221 *0.27*	0.0196 *0.32*	0.0456 *0.45*	0.0521 *0.40*
QUARTER1	-0.0172 *0.39*	-0.0198 *0.39*	-0.0167 *0.47*	-0.0050 *0.79*	-0.0023 *0.91*	-0.0019 *0.92*	-0.0047 *0.82*
QUARTER2	-0.0528 *0.02*	-0.0535 *0.02*	-0.0497 *0.04*	-0.0379 *0.03*	-0.0347 *0.08*	-0.0419 *0.07*	-0.0424 *0.05*
QUARTER3	-0.0886 *0.00*	-0.0901 *0.00*	-0.0895 *0.00*	-0.0771 *0.00*	-0.0756 *0.00*	-0.0674 *0.00*	-0.0678 *0.00*
OILSHOCK	-0.0320 *0.03*	-0.0339 *0.02*	-0.0316 *0.01*	-0.0293 *0.00*	-0.0285 *0.00*	-0.0343 *0.01*	-0.0367 *0.01*
Adjusted R-squared	0.4542	0.4463	0.4526	0.4568	0.4517	0.5286	0.5227
Wald F-Statistic F-Statistic (for IV)	4.2024 *0.00*	4.0587 *0.00*	4.7729 *0.00*	6.4258 *0.00*	6.4861 *0.00*	5.3138 *0.00*	5.2120 *0.00*
DW-Stat	2.4290	2.3941	2.4113	2.3894	2.3982	2.2735	2.1801
Instrument Variable	log(OILP)				log(DIE SELP)	log(OILP)	
Endogeneity Test	*0.94*	*0.90*	*0.75*	*0.62*	*0.29*	*0.91*	*0.84*

Table C23. Time Series Analysis for Central Region with Quarterly Data, 2003-2015, IV Models 8-10 and Asymmetric Models 1-4

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV8	IV9	IV10	Asym1	Asym2	Asym3	Asym4
C	0.0451 *0.02*	0.0466 *0.00*	0.0436 *0.02*	0.0579 *0.00*	0.0590 *0.00*	0.0589 *0.00*	0.0497 *0.00*
d(log(GASP))	-0.1888 *0.78*	-0.0507 *0.52*	-0.0973 *0.34*				
d(log(GASPCUT))				0.1496 *0.22*	-0.1304 *0.49*	-0.0585 *0.46*	-0.0561 *0.48*
d(log(GASPREC))				-0.1068 *0.55*	-0.3815 *0.13*	-0.2602 *0.15*	-0.2604 *0.15*
d(log(GDP))	-0.8141 *0.08*	-0.8592 *0.03*	-0.8978 *0.04*	-0.7670 *0.07*	-0.8087 *0.05*	-1.0019 *0.04*	-0.9984 *0.04*
d(log(DIESELP))				-0.2261 *0.05*			
D(log(DIESELP)/ log(GASP))					-0.7194 *0.08*		
d(log(LPGP))				-0.2458 *0.25*			
D(log(LPGP)/ log(GASP))	-0.6015 *0.83*				-0.3159 *0.72*		
d(log(NATGASP))	0.0848 *0.81*	0.0171 *0.87*	-0.0069 *0.96*	0.1496 *0.39*	0.0833 *0.57*	0.0015 *0.99*	0.0103 *0.94*
D(log(NATGASP)/ log(GASP))							
d(log(TRANSITP))	0.5782 *0.12*	0.6325 *0.05*	0.6796 *0.04*	0.8342 *0.04*	0.8757 *0.04*	0.6064 *0.05*	0.6184 *0.05*
d(log(VEHP(-3)))	-0.0520 *0.02*	-0.0528 *0.01*	-0.0494 *0.03*				
d(NEWVEHQPC (-3))				-14.524 *0.45*	-15.103 *0.43*	-18.891 *0.32*	
d(AGGDP%)	0.0755 *0.05*	0.0768 *0.05*	0.0827 *0.06*	0.0838 *0.03*	0.0848 *0.04*	0.0966 *0.04*	0.0969 *0.05*
d(UNEMP%)	0.0402 *0.51*	0.0445 *0.41*	0.0346 *0.54*	0.0339 *0.55*	0.0375 *0.51*	0.0374 *0.50*	0.0365 *0.50*
QUARTER1	0.0021 *0.93*	-0.0006 *0.98*	0.0032 *0.89*	-0.0161 *0.46*	-0.0173 *0.43*	-0.0184 *0.43*	-0.0081 *0.73*
QUARTER2	-0.0376 *0.11*	-0.0385 *0.09*	-0.0347 *0.17*	-0.0496 *0.03*	-0.0500 *0.04*	-0.0490 *0.05*	-0.0388 *0.08*
QUARTER3	-0.0649 *0.00*	-0.0653 *0.00*	-0.0649 *0.00*	-0.0890 *0.00*	-0.0902 *0.00*	-0.0895 *0.00*	-0.0755 *0.00*
OILSHOCK	-0.0329 *0.02*	-0.0344 *0.00*	-0.0340 *0.00*	-0.0323 *0.02*	-0.0337 *0.02*	-0.0310 *0.02*	-0.0310 *0.02*
Adjusted R-squared	0.5271	0.5410	0.5369	0.4643	0.4563	0.4560	0.4638
Wald F-Statistic F-Statistic (for IV)	5.6564 *0.00*	6.3568 *0.00*	6.3424 *0.00*	10.2600 *0.00*	9.4671 *0.00*	8.6137 *0.00*	9.6496 *0.00*
DW-Stat	2.2729	2.2163	2.2452	2.5389	2.5187	2.5219	2.5281

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV8	IV9	IV10	Asym1	Asym2	Asym3	Asym4
AIC				-3.3486	-3.3338	-3.3574	-3.3852
Instrument Variable	log(OILP)		log(DIE SELP)				
Endogeneity Test	*0.88*	*0.90*	*0.47*				
Wald Test (H0: GASPCUT =GASPREC)				*0.18*	*0.19*	*0.30*	*0.29*

Table C24. Time Series Analysis for Central Region with Quarterly Data, 2003-2015, Asymmetric Models 5-7

Central Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym5	Asym6	Asym7				
C	0.0617 *0.00*	0.0627 *0.00*	0.0613 *0.00*				
d(log(GASPCUT))	0.3279 *0.03*	0.1836 *0.37*	0.1948 *0.03*				
d(log(GASPREC))	-0.2219 *0.12*	-0.3703 *0.07*	-0.3337 *0.02*				
d(log(GDP))	-0.9186 *0.05*	-0.9554 *0.04*	-1.0787 *0.03*				
d(log(DIESELP))	-0.1583 *0.11*						
D(log(DIESELP)/ log(GASP))		-0.5237 *0.13*					
d(log(LPGP))	-0.1424 *0.57*						
D(log(LPGP)/ log(GASP))		-0.0010 *0.99*					
d(log(NATGASP))	0.1548 *0.39*	0.0976 *0.57*	0.0683 *0.56*				
d(log(TRANSITP))	0.8683 *0.04*	0.9193 *0.03*	0.7055 *0.04*				
d(log(VEHP(-3)))	-0.0739 *0.00*	-0.0752 *0.00*	-0.0782 *0.00*				
d(AGGDP%)	0.0793 *0.07*	0.0801 *0.09*	0.0875 *0.07*				
d(UNEMP%)	0.0220 *0.65*	0.0247 *0.61*	0.0229 *0.64*				
QUARTER1	0.0020 *0.91*	0.0010 *0.96*	0.0030 *0.89*				
QUARTER2	-0.0355 *0.08*	-0.0357 *0.08*	-0.0330 *0.13*				
QUARTER3	-0.0654 *0.00*	-0.0658 *0.00*	-0.0627 *0.00*				
OILSHOCK	-0.0363 *0.01*	-0.0377 *0.01*	-0.0353 *0.01*				
Adjusted R-squared	0.6110	0.6093	0.6146				
Wald F-Statistic F-Statistic (for IV)	28.0077 *0.00*	25.5765 *0.00*	36.9059 *0.00*				
DW-Stat	2.2506	2.1975	2.1645				
AIC	-3.6685	-3.6640	-3.7023				
Wald Test (H0: GASPCUT =GASPREC)	*0.00*	*0.00*	*0.00*				

Table C25. Time Series Analysis for Northeastern Region with Annual Data, 2004-2015, Simple Models 1-5 and IV Models 1 & 2

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	Simple3	Simple4	**Simple5**	IV1	IV2
C	0.0292 *0.38*	0.0214 *0.43*	0.0112 *0.68*	0.0084 *0.75*	**0.0076** ***0.67*‡**	0.0291 *0.38*	0.0220 *0.39*
d(log(GASP))	-0.5959 *0.15*	-1.5977 *0.17*	-0.4546 *0.14*	-0.8277 *0.12*	**-0.3778** ***0.00***	-0.6448 *0.14*	-1.7125 *0.11*
d(log(GDP))	1.3218 *0.31*	1.5689 *0.28*	0.1596 *0.87*	0.3106 *0.76*	**0.4288** ***0.13***	1.4411 *0.24*	1.7200 *0.19*
d(log(DIESELP))	0.3417 *0.50*	0.4307 *0.44*	-0.0985 *0.73*			0.3998 *0.41*	0.4919 *0.33*
D(log(DIESELP)/ log(GASP))				-0.0734 *0.94*			
d(log(LPGP))	-1.3071 *0.21*					-1.3486 *0.17*	
D(log(LPGP)/ log(GASP))		-4.1811 *0.20*					-4.5453 *0.13*
d(log(NATGASP))	0.1769 *0.55*	0.1001 *0.67*	-0.3774 *0.31*			0.1754 *0.52*	0.1352 *0.43*
D(log(NATGASP)/ log(GASP))				-1.3502 *0.29*			
d(log(TRANSITP))	0.0752 *0.63*	0.0180 *0.91*	0.3097 *0.18*	0.2560 *0.25*	**0.2972** ***0.30***	0.0449 *0.79*	-0.0152 *0.91*
d(log(VEHP))							
d(VEHQPC)	0.3248 *0.94*	0.0201 *0.99*	5.1413 *0.48*	4.8566 *0.51*	**3.6869** ***0.23***	-0.0492 *0.99*	-0.5019 *0.87*
d(AGGDP%)	0.0061 *0.60*	0.0010 *0.93*	0.0069 *0.84*	0.0053 *0.88*	**-0.0118** ***0.30***	0.0062 *0.61*	0.0005 *0.95*
d(UNEMP%)	0.2096 *0.39*	0.1996 *0.39*	-0.0705 *0.54*	-0.0658 *0.59*	**-0.0298** ***0.07***	0.2257 *0.35*	0.2256 *0.29*
OILSHOCK	-0.0051 *0.91*	-0.0079 *0.87*	0.0080 *0.85*	0.0073 *0.87*	**0.0009** ***0.96***	-0.0059 *0.90*	-0.0094 *0.83*
Adjusted R-squared	0.8103	0.8201	0.4206	0.4130	**0.5528**	0.7997	0.8115
Wald F-Statistic F-Statistic (for IV)	273.056 *0.05*	290.666 *0.05*	108.038 *0.01*	163.778 *0.01*	**67.0715** ***0.00***	*5.4827* *0.32*	5.8249 *0.31*
DW-Stat	2.5810	2.5881	1.7598	1.8360	**1.2060**	2.8930	2.7598
AIC	-5.1742	-5.2269	-3.5311	-3.5181	**-3.4041**		
Instrument Variable						log(OILP)	
Endogeneity Test						*0.32*	*0.32*

Table C26. Time Series Analysis for Northeastern Region with Annual Data, 2004-2015, IV Models 3-5 and Asymmetric Models 1-4

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV3	IV4	IV5	Asym1	Asym2	Asym3	Asym4
C	0.0031 *0.94*	0.0023 *0.96*	-0.0008 *0.96*	0.0784 *0.08*	0.0640 *0.19*‡	-0.0156 *0.82*	0.0141 *0.57*
d(log(GASP))	-0.9653 *0.21*	-1.6743 *0.17*	-0.6860 *0.31*				
d(log(GASPCUT))				-0.4949 *0.03*	-1.8439 *0.04*	-0.9899 *0.11*	-0.3378 *0.06*
d(log(GASPREC))				-1.2779 *0.06*	-2.6003 *0.10*	-0.5381 *0.50*	-0.4623 *0.05*
d(log(GDP))	1.1088 *0.51*	1.1984 *0.63*	0.7994 *0.37*	1.2995 *0.02*	1.5801 *0.04*	0.5924 *0.53*	0.4158 *0.14*
d(log(DIESELP))	0.4087 *0.56*	0.4938 *0.62*	0.2255 *0.62*	0.5570 *0.05*	0.6509 *0.11*		
D(log(DIESELP)/ log(GASP))						-0.1534 *0.85*	
d(log(LPGP))				-1.8129 *0.03*			
D(log(LPGP)/ log(GASP))					-5.6386 *0.07*		
d(log(NATGASP))	-0.5970 *0.21*			0.5069 *0.08*	0.3793 *0.21*		
D(log(NATGASP)/ log(GASP))		-2.7345 *0.13*				-1.5773 *0.22*	
d(log(TRANSITP))	0.0469 *0.93*	-0.0371 *0.96*	0.1754 *0.68*	-0.1718 *0.19*	-0.2435 *0.30*	0.3475 *0.10*	0.3183 *0.27*
d(log(VEHP))							
d(VEHQPC)	2.5938 *0.70*	2.7589 *0.77*	1.7855 *0.73*	-3.9791 *0.13*	-3.9208 *0.27*	6.1991 *0.38*	3.4799 *0.33*
d(NEWVEHQPC)							
d(AGGDP%)	0.0092 *0.85*	0.0155 *0.80*	-0.0134 *0.32*	0.0168 *0.10*	0.0103 *0.31*	-0.0016 *0.96*	-0.0108 *0.47*
d(UNEMP%)	0.0117 *0.96*	0.0015 *0.99*	-0.0286 *0.17*	0.1766 *0.05*	0.1549 *0.12*	0.0143 *0.94*	-0.0283 *0.18*
OILSHOCK	0.0035 *0.97*	0.0029 *0.98*	0.0059 *0.78*				0.0022 *0.93*
Adjusted R-squared	-0.2184	-0.4908	0.1519	0.9976	0.9880	0.4646	0.4747
Wald F-Statistic F-Statistic (for IV)	1.0013 *0.59*	0.8141 *0.66*	1.7989 *0.27*	34829.0 *0.00*	10230.6 *0.01*	87.4142 *0.01*	69.1094 *0.00*
DW-Stat	3.0304	3.2159	1.4536	2.7474	2.7719	1.9150	1.2367
AIC				-9.5639	-7.9365	-3.6102	-3.2827
Instrument Variable	log(OILP)						

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV3	IV4	IV5	Asym1	Asym2	Asym3	Asym4
Endogeneity Test	*0.16*	*0.16*	*0.05*				
Wald Test (H0: GASPCUT =GASPREC)				*0.11*	*0.23*	*0.64*	*0.68*

Table C27. Time Series Analysis for Northeastern Region with Quarterly Data, 2003-2015, Simple Models 1-7

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	Simple3	**Simple4**	Simple5	Simple6	**Simple7**
C	0.0717 *0.00*	0.0714 *0.00*	0.0683 *0.00*	**0.0635** ***0.00***	0.0609 *0.00*	0.0598 *0.00*	**0.0580** ***0.00***
d(log(GASP))	-0.1472 *0.44*	-0.7101 *0.01*	-0.2582 *0.31*	**-0.2175** ***0.03***	-0.0900 *0.64*	-0.6220 *0.02*	**-0.2066** ***0.06***
d(log(GDP))	0.1594 *0.81*	0.2486 *0.71*	0.4299 *0.51*	**0.7003** ***0.21***	0.2138 *0.75*	0.2898 *0.67*	**0.4899** ***0.48***
d(log(DIESELP))	-0.1422 *0.43*				-0.1610 *0.37*		
D(log(DIESELP)/ log(GASP))		-0.3764 *0.57*				-0.4879 *0.45*	
d(log(LPGP))	-0.6558 *0.08*				-0.6034 *0.10*		
D(log(LPGP)/ log(GASP))		-2.0750 *0.21*				-1.8344 *0.15*	
d(log(NATGASP))	0.2430 *0.51*	0.2055 *0.57*			0.2824 *0.43*	0.2477 *0.49*	**0.0082** ***0.97***
D(log(NATGASP)/ log(GASP))			-0.0543 *0.95*				
d(log(TRANSITP))	0.8211 *0.03*	0.8026 *0.03*	0.7489 *0.02*	**0.7312** ***0.02***	1.0869 *0.00*	1.0987 *0.00*	**0.9901** ***0.00***
d(log(VEHP(-3)))					-0.0396 *0.02*	-0.0406 *0.01*	**-0.0419** ***0.01***
d(NEWVEHQPC(-3))	-35.117 *0.14*	-38.617 *0.14*	-33.967 *0.15*				
d(AGGDP%)	-0.0045 *0.79*	-0.0053 *0.77*	-0.0068 *0.73*	**-0.0141** ***0.20***	-0.0141 *0.46*	-0.0156 *0.43*	**-0.0150** ***0.47***
d(UNEMP%)	0.0108 *0.39*	0.0108 *0.39*	0.0120 *0.35*	**0.0066** ***0.13***	0.0135 *0.35*	0.0138 *0.34*	**0.0144** ***0.32***
QUARTER1	-0.0918 *0.00*	-0.0895 *0.00*	-0.0947 *0.01*	**-0.0827** ***0.00***	-0.0802 *0.00*	-0.0779 *0.00*	**-0.0819** ***0.00***
QUARTER2	-0.0361 *0.23*	-0.0360 *0.24*	-0.0294 *0.32*	**-0.0174** ***0.47***	-0.0200 *0.36*	-0.0186 *0.38*	**-0.0142** ***0.51***
QUARTER3	-0.1099 *0.00*	-0.1126 *0.00*	-0.1051 *0.00*	**-0.1014** ***0.00***	-0.0812 *0.00*	-0.0817 *0.00*	**-0.0770** ***0.00***
OILSHOCK	-0.0134 *0.32*	-0.0141 0.30	-0.0156 0.20	**-0.0218** ***0.15***	-0.0159 *0.24*	-0.0168 *0.22*	**-0.0182** ***0.16***
Adjusted R-squared	0.4260	0.4188	0.4094	**0.4585**	0.4580	0.4504	**0.4451**
Wald F-Statistic F-Statistic (for IV)	7.2314 *0.00*	7.2368 *0.00*	6.1646 *0.00*	**6.8610** ***0.00***	15.7505 *0.00*	15.5164 *0.00*	**14.3746** ***0.00***
DW-Stat	2.6753	2.6850	2.5351	**2.5920**	2.6411	2.6471	**2.4646**
AIC	-2.9975	-2.9850	-2.9946	**-3.0809**	-3.0548	-3.0409	**-3.0570**

Table C28. Time Series Analysis for Northeastern Region with Quarterly Data, 2003-2015, IV Models 1-7

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV1	IV2	IV3	IV4	IV5	IV6	IV7
C	0.0744 *0.00*	0.0718 *0.00*	0.0663 *0.00*	0.0561 *0.00*	0.0558 *0.00*	0.0649 *0.00*	0.0614 *0.00*
d(log(GASP))	-0.0376 *0.87*	-0.4406 *0.31*	-0.1378 *0.73*	-0.1558 *0.70*	-0.3491 *0.28*	0.0179 *0.94*	-0.3489 *0.52*
d(log(GDP))	0.0307 *0.97*	0.3033 *0.64*	0.4536 *0.48*	0.4803 *0.46*	0.4520 *0.51*	0.0853 *0.91*	0.3452 *0.60*
d(log(DIESELP))	-0.2373 *0.20*					-0.2529 *0.19*	
D(log(DIESELP)/ log(GASP))		-0.2504 *0.75*					-0.3539 *0.66*
d(log(LPGP))	-0.6828 *0.07*					-0.6307 *0.08*	
D(log(LPGP)/ log(GASP))		-0.9799 *0.56*					-0.7329 *0.73*
d(log(NATGASP))	0.2912 *0.45*	0.0901 *0.77*				0.3247 *0.37*	0.1268 *0.71*
D(log(NATGASP)/ log(GASP))			0.3210 *0.81*	0.3113 *0.81*	-0.2758 *0.80*		
d(log(TRANSITP))	0.9098 *0.03*	0.7623 *0.04*	0.6701 *0.04*	0.7052 *0.02*	0.8391 *0.00*	1.1782 *0.00*	1.0674 *0.00*
d(log(VEHP(-3)))						-0.0410 *0.02*	-0.0429 *0.02*
d(NEWVEHQPC (-3))	-31.400 *0.17*	-35.579 *0.16*	-28.107 *0.25*				
d(AGGDP%)	-0.0056 *0.76*	-0.0058 *0.75*	-0.0112 *0.64*	-0.0148 *0.51*	-0.0091 *0.68*	-0.0146 *0.47*	-0.0158 *0.44*
d(UNEMP%)	0.0121 *0.32*	0.0122 *0.34*	0.0129 *0.33*	0.0137 *0.30*	0.0125 *0.33*	0.0147 *0.30*	0.0151 *0.30*
QUARTER1	-0.0955 *0.00*	-0.0949 *0.00*	-0.0976 *0.01*	-0.0898 *0.01*	-0.0828 *0.02*	-0.0845 *0.00*	-0.0836 *0.00*
QUARTER2	-0.0378 *0.22*	-0.0343 *0.28*	-0.0279 *0.31*	-0.0155 *0.49*	-0.0140 *0.56*	-0.0233 *0.30*	-0.0182 *0.41*
QUARTER3	-0.1104 *0.00*	-0.1096 *0.00*	-0.0998 *0.00*	-0.0833 *0.00*	-0.0863 *0.00*	-0.0836 *0.00*	-0.0802 *0.00*
OILSHOCK	-0.0145 *0.32*	-0.0155 *0.25*	-0.0139 *0.22*	-0.0139 *0.22*	-0.0164 *0.20*	-0.0171 *0.25*	-0.0184 *0.20*
Adjusted R-squared	0.4203	0.4067	0.4035	0.4106	0.4045	0.4523	0.4380
Wald F-Statistic F-Statistic (for IV)	3.7670 *0.00*	3.3348 *0.00*	3.9714 *0.00*	4.3917 *0.00*	4.4749 *0.00*	4.1859 *0.00*	3.7591 *0.00*
DW-Stat	2.7095	2.6495	2.5996	2.6002	2.4721	2.6736	2.5833
Instrument Variable	log(OILP)				log(DIE SELP)	log(OILP)	
Endogeneity Test	0.56	0.57	*0.55*	*0.79*	*0.51*	*0.59*	*0.60*

Table C29. Time Series Analysis for Northeastern Region with Quarterly Data, 2003-2015, IV Models 8-10 and Asymmetric Models 1-4

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV8	IV9	IV10	Asym1	Asym2	Asym3	Asym4
C	0.0593 *0.00*	0.0571 *0.00*	0.0540 *0.01*	0.0690 *0.01*	0.0690 *0.01*	0.0659 *0.01*	0.0635 *0.00*
d(log(GASP))	-0.1782 *0.22*	-0.3032 *0.34*	-0.2468 *0.03*				
d(log(GASPCUT))				-0.1921 *0.34*	-0.7519 *0.00*	-0.3081 *0.28*	-0.2171 *0.08*
d(log(GASPREC))				-0.0828 *0.79*	-0.6541 *0.06*	-0.2153 *0.47*	-0.2179 *0.26*
d(log(GDP))	0.4817 *0.49*	0.4818 *0.49*	0.7066 *0.24*	0.1211 *0.87*	0.2117 *0.78*	0.4051 *0.57*	0.7006 *0.25*
d(log(DIESELP))				-0.1494 *0.44*			
D(log(DIESELP)/ log(GASP))					-0.4081 *0.57*		
d(log(LPGP))				-0.6546 *0.08*			
D(log(LPGP)/ log(GASP))					-2.0511 *0.13*		
d(log(NATGASP))	0.0196 *0.93*			0.2299 *0.54*	0.1925 *0.61*		
D(log(NATGASP)/ log(GASP))		-0.2390 *0.82*				-0.0912 *0.92*	
d(log(TRANSITP))	0.9542 *0.00*	1.0591 *0.00*	1.0435 *0.00*	0.8897 *0.06*	0.8699 *0.08*	0.7973 *0.03*	0.7308 *0.05*
d(log(VEHP(-3)))	-0.0431 *0.02*	-0.0400 *0.04*	-0.0397 *0.03*				
d(NEWVEHQPC (-3))				-34.827 *0.15*	-38.210 *0.15*	-33.914 *0.15*	
d(AGGDP%)	-0.0152 *0.46*	-0.0124 *0.59*	-0.0211 *0.19*	-0.0052 *0.76*	-0.0060 *0.73*	-0.0074 *0.71*	-0.0141 *0.21*
d(UNEMP%)	0.0150 *0.31*	0.0136 *0.34*	0.0161 *0.27*	0.0125 *0.41*	0.0123 *0.42*	0.0134 *0.36*	0.0066 *0.18*
QUARTER1	-0.0839 *0.00*	-0.0780 *0.01*	-0.0802 *0.00*	-0.0925 *0.00*	-0.0903 *0.00*	-0.0952 *0.00*	-0.0827 *0.00*
QUARTER2	-0.0155 *0.48*	-0.0128 *0.57*	-0.0115 *0.64*	-0.0359 *0.25*	-0.0358 *0.26*	-0.0293 *0.33*	-0.0174 *0.47*
QUARTER3	-0.0772 *0.00*	-0.0784 *0.00*	-0.0752 *0.00*	-0.1092 *0.00*	-0.1185 *0.00*	-0.1045 *0.00*	-0.1014 *0.00*
OILSHOCK	-0.0184 *0.16*	-0.0191 *0.16*	-0.0174 *0.23*	-0.0144 *0.32*	-0.0151 *0.30*	-0.0164 *0.18*	-0.0218 *0.17*
Adjusted R-squared	0.4440	0.4385	0.4573	0.4129	0.4049	0.3958	0.4472
Wald F-Statistic F-Statistic (for IV)	4.4826 *0.00*	4.6286 *0.00*	5.2810 *0.00*	13.8389 *0.00*	14.3432 *0.00*	9.9154 *0.00*	7.0967 *0.00*
DW-Stat	2.4808	2.4037	2.6104	2.6884	2.6951	2.5491	2.5920

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV8	IV9	IV10	Asym1	Asym2	Asym3	Asym4
AIC				-2.9631	-2.9495	-2.9586	-3.0470
Instrument Variable	log(DIESELP)	log(OILP)	log(DIESELP)				
Endogeneity Test	*0.63*	*0.51*	*0.58*				
Wald Test (H0: GASPCUT =GASPREC)				*0.72*	*0.76*	*0.74*	*0.99*

Table C30. Time Series Analysis for Northeastern Region with Quarterly Data, 2003-2015, Asymmetric Models 5-7

Northeastern Region d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym5	Asym6	Asym7				
C	0.0615 *0.00*	0.0607 *0.00*	0.0591 *0.00*				
d(log(GASPCUT))	-0.0794 *0.68*	-0.6050 *0.03*	-0.1848 *0.23*				
d(log(GASPREC))	-0.1039 *0.72*	-0.6412 *0.05*	-0.2298 *0.22*				
d(log(GDP))	0.2232 *0.77*	0.3042 *0.69*	0.5031 *0.50*				
d(log(DIESELP))	-0.1593 *0.39*						
D(log(DIESELP)/ log(GASP))		-0.4768 *0.48*					
d(log(LPGP))	-0.6031 *0.10*						
D(log(LPGP)/ log(GASP))		-1.8401 *0.16*					
d(log(NATGASP))	0.2852 *0.44*	0.2525 *0.50*	0.0142 *0.95*				
d(log(TRANSITP))	1.0753 *0.01*	1.0797 *0.01*	0.9735 *0.01*				
d(log(VEHP(-3)))	-0.0403 *0.03*	-0.0416 *0.02*	-0.0431 *0.02*				
d(AGGDP%)	-0.0140 *0.47*	-0.0155 *0.44*	-0.0148 *0.48*				
d(UNEMP%)	0.0131 *0.44*	0.0132 *0.44*	0.0138 *0.40*				
QUARTER1	-0.0799 *0.00*	-0.0774 *0.00*	-0.0815 *0.00*				
QUARTER2	-0.0200 *0.36*	-0.0186 *0.39*	-0.0142 *0.51*				
QUARTER3	-0.0812 *0.00*	-0.0817 *0.00*	-0.0771 *0.00*				
OILSHOCK	-0.0157 *0.27*	-0.0165 *0.24*	-0.0179 *0.17*				
Adjusted R-squared	0.4431	0.4354	0.4309				
Wald F-Statistic F-Statistic (for IV)	27.5625 *0.00*	27.2024 *0.00*	28.0892 *0.00*				
DW-Stat	2.6324	2.6346	2.4472				
AIC	-3.0158	-3.0022	-3.0186				
Wald Test (H0: GASPCUT =GASPREC)	*0.93*	*0.91*	*0.86*				

Table C31. Time Series Analysis for Bangkok with Annual Data, 2004-2015, Simple Models 1-7

Bangkok d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	Simple4	Simple5	Simple6	**Simple7**
C	-0.0162 *0.46*	-0.0200 *0.41*	**-0.0529** ***0.06***	-0.0666 *0.04*	-0.0676 *0.05‡*	-0.0669 *0.01*	**-0.0692** ***0.00***
d(log(GASP))	-0.1673 *0.34*	-0.8321 *0.23*	**-0.1585** ***0.11***	-0.1552 *0.15*	-0.1704 *0.25*	-0.2374 *0.10*	**-0.1885** ***0.00***
d(log(GDP))	0.6252 *0.26*	0.5689 *0.39*	**-0.0468** ***0.96***	1.1904 *0.06*	1.1851 *0.06*	1.2034 *0.01*	**1.2011** ***0.00***
d(log(DIESELP))	-0.2928 *0.05*			-0.0396 *0.48*			
D(log(DIESELP)/ log(GASP))		-0.8177 *0.09*			-0.1470 *0.43*		
d(log(LPGP))	1.2390 *0.15*	1.1106 *0.18*	**0.8140** ***0.07***	0.5464 *0.07*	0.5225 *0.08*	0.5834 *0.01*	**0.5485** ***0.00***
D(log(LPGP)/ log(GASP))							
d(log(NATGASP))	-0.6757 *0.24*			-0.0088 *0.88*			
D(log(NATGASP)/ log(GASP))		-1.9791 *0.28*			0.0599 *0.81*	-0.1489 *0.62*	
d(log(TRANSITP))	0.4709 *0.26*	0.3632 *0.33*	**-0.0584** ***0.75***				
D(TRANSITQ)				-2.0e-7 *0.10*	-2.0e-7 *0.10*	-2.1e-7 *0.01*	**-2.2e-7** ***0.00***
d(VEHQPC(-1))	-0.3000 *0.69*	-0.1592 *0.85*	**1.0683** ***0.03***	0.5387 *0.18*	0.5716 *0.17*	0.5077 *0.07*	**0.5733** ***0.00***
d(AGGDP%)	-4.0380 *0.33*	-3.9913 *0.43*	**-2.8337** ***0.64***	-5.5090 *0.09*	-5.5454 *0.09*	-5.3982 *0.02*	**-5.4527** ***0.00***
d(UNEMP%)	-0.1040 *0.21*	-0.1152 *0.27*	**-0.1515** ***0.08***	-0.0694 *0.14*	-0.0667 *0.16*	-0.0770 *0.02*	**-0.0727** ***0.00***
OILSHOCK	-0.0292 *0.40*	-0.0240 *0.49*	**0.0020** ***0.95***	0.0079 *0.25*	0.0086 *0.27*	0.0056 *0.43*	**0.0069** ***0.15***
Adjusted R-squared	0.9151	0.8497	**0.5595**	0.9878	0.9877	0.9838	**0.9885**
Wald F-Statistic F-Statistic (for IV)	340.217 *0.04*	162.143 *0.06*	**43.8381** ***0.01***	918.925 *0.03*	667.662 *0.03*	1718.31 *0.00*	**1571.13** ***0.00***
DW-Stat	2.3368	2.5118	**2.7137**	1.9313	1.8622	1.6625	**1.5484**
AIC	-6.1555	-5.5836	**-3.7433**	-8.0974	-8.0876	-7.2834	**-7.3866**

Table C32. Time Series Analysis for Bangkok with Annual Data, 2004-2015,
IV Models 1-6 and Asymmetric Model 1

Bangkok d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV1	IV2	IV3	IV4	IV5	IV6	Asym1
C	-0.0155 *0.50*	-0.0175 *0.53*	-0.0552 *0.07*	-0.0572 *0.08*	-0.0690 *0.00*‡	-0.0703 *0.00*	-0.0922 *0.04*
d(log(GASP))	-0.1840 *0.33*	-0.9078 *0.27*	-0.2235 *0.13*	-0.2790 *0.14*	-0.1835 *0.00*	-0.2128 *0.01*	
d(log(GASPCUT))							0.1850 *0.08*
d(log(GASPREC))							1.0434 *0.06*
d(log(GDP))	0.6341 *0.25*	0.6060 *0.34*	-0.0322 *0.97*	-0.0197 *0.98*	1.1966 *0.00*	1.2225 *0.00*	0.1621 *0.22*
d(log(DIESELP))	-0.2872 *0.06*						-0.4552 *0.02*
D(log(DIESELP)/ log(GASP))		-0.7951 *0.10*					
d(log(LPGP))	1.2588 *0.15*	1.1578 *0.20*	0.7852 *0.07*	0.7606 *0.08*	0.5514 *0.00*	0.5347 *0.00*	0.5339 *0.04*
d(log(NATGASP))	-0.6989 *0.26*						0.1936 *0.17*
D(log(NATGASP)/ log(GASP))		-2.2010 *0.34*					
d(log(TRANSITP))	0.4723 *0.26*	0.3748 *0.35*	-0.0642 *0.74*	-0.0693 *0.75*			0.1835 *0.04*
D(TRANSITQ)					-2.2e-7 *0.00*	-2.2e-7 *0.00*	
d(VEHQPC(-1))	-0.3364 *0.67*	-0.2660 *0.78*	0.9914 *0.05*	0.9256 *0.08*	0.5804 *0.00*	0.5388 *0.00*	2.1376 *0.06*
d(AGGDP%)	-4.0007 *0.33*	-3.9577 *0.42*	-2.6029 *0.69*	-2.4057 *0.72*	-5.4633 *0.00*	-5.4018 *0.00*	-7.9027 *0.04*
d(UNEMP%)	-0.1069 *0.19*	-0.1202 *0.24*	-0.1666 *0.06*	-0.1795 *0.05*	-0.0717 *0.00*	-0.0771 *0.01*	-0.0245 *0.21*
OILSHOCK	-0.0299 *0.41*	-0.0262 *0.51*	0.0070 *0.80*	0.0113 *0.70*	0.0065 *0.19*	0.0087 *0.07*	
Adjusted R-squared	0.9142	0.8452	0.5246	0.4397	0.9883	0.9837	0.9983
Wald F-Statistic F-Statistic (for IV)	12.7368 *0.21*	7.0616 *0.29*	2.6791 *0.23*	2.3141 *0.26*	115.796 *0.00*	82.4818 *0.00*	9034.73 *0.01*
DW-Stat	2.2577	2.3013	2.3102	2.0054	1.7934	0.8865	2.1331
Instrument Variable	log(OILP)			log(DIE SELP)	log(OILP)	log(DIE SELP)	
Endogeneity Test	*0.32*	*0.32*	*0.11*	*0.18*	*0.36*	*0.16*	
Wald Test (H0: GASPCUT =GASPREC)							*0.06*

Table C33. Time Series Analysis for Bangkok with Annual Data, 2004-2015, Asymmetric Models 2-5

Bangkok d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Asym2	Asym3	Asym4	Asym5			
C	-0.0908 *0.06*	-0.0287 *0.57*	-0.0621 *0.31*	-0.0653 *0.00*			
d(log(GASPCUT))	-0.2348 *0.06*	-0.8102 *0.20*	-0.1885 *0.13*	-0.1756 *0.01*			
d(log(GASPREC))	0.6089 *0.14*	-0.9865 *0.34*	-0.0101 *0.99*	-0.2597 *0.05*			
d(log(GDP))	0.1560 *0.33*	0.4778 *0.68*	-0.0675 *0.95*	1.2610 *0.01*			
d(log(DIESELP))							
D(log(DIESELP)/ log(GASP))	-1.5651 *0.03*						
d(log(LPGP))	0.4748 *0.08*	1.1861 *0.07*	0.8258 *0.11*	0.5301 *0.01*			
D(log(LPGP)/ log(GASP))							
d(log(NATGASP))	0.2355 *0.21*						
D(log(NATGASP)/ log(GASP))		-1.9554 *0.32*					
d(log(TRANSITP))	0.1782 *0.06*	0.0787 *0.61*	-0.0955 *0.75*				
D(TRANSITQ)				-2.2e-7 *0.00*			
d(VEHQPC(-1))	2.1149 *0.09*	-0.1285 *0.93*	1.3050 *0.34*	0.4384 *0.04*			
d(AGGDP%)	-7.9348 *0.06*	-2.4043 *0.70*	-3.4569 *0.70*	-5.2599 *0.03*			
d(UNEMP%)	-0.0217 *0.34*	-0.1758 *0.12*	-0.1505 *0.19*	-0.0714 *0.03*			
OILSHOCK			0.0011 *0.97*	0.0084 *0.14*			
Adjusted R-squared	0.9962	0.5815	0.3631	0.9891			
Wald F-Statistic F-Statistic (for IV)	4131.77 *0.01*	518.700 *0.00*	34.7758 *0.03*	764.570 *0.00*			
DW-Stat	2.1489	2.4479	2.7442	1.3437			
AIC	-9.2682	-4.0333	-3.6134	-7.6802			
Wald Test (H0: GASPCUT =GASPREC)	*0.09*	*0.72*	*0.82*	*0.30*			

Table C34. Time Series Analysis for Bangkok with Quarterly Data, 2003-2015,
Simple Models 1-4 and IV Models 1-3

Bangkok d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	Simple1	Simple2	**Simple3**	**Simple4**	IV1	IV2	IV3
C	-0.0147 *0.49*	-0.0147 *0.50*	**-0.0150** ***0.47***	**-0.0144** ***0.45***	-0.0181 *0.44*	-0.0107 *0.71*	-0.0195 *0.39*
d(log(GASP))	-0.1427 *0.49*	-0.1568 *0.58*	**-0.1351** ***0.47***	**-0.0668** ***0.74***	-0.4754 *0.01*	-1.2813 *0.09*	-0.4104 *0.01*
d(log(GDP))	1.0888 *0.15*	1.0825 *0.15*	**1.0710** ***0.15***	**0.7501** ***0.39***	0.9024 *0.31*	1.1268 *0.30*	0.8324 *0.33*
d(log(DIESELP))	0.1413 *0.41*	0.1399 *0.42*	**0.1344** ***0.38***	**0.0712** ***0.64***	0.4057 *0.06*	0.6345 *0.10*	0.3500 *0.07*
d(log(LPGP))	0.7279 *0.05*	0.7135 *0.05*	**0.6927** ***0.04***	**0.7567** ***0.02***	0.7947 *0.09*	1.3040 *0.07*	0.6195 *0.12*
d(log(NATGASP))	-0.0362 *0.85*				-0.1873 *0.24*		
D(log(NATGASP)/ log(GASP))		-0.0803 *0.90*				-2.7735 *0.17*	
d(log(TRANSITP))	-0.9024 *0.00*	-0.9034 *0.00*	**-0.9016** ***0.00***	**-0.8358** ***0.00***	-1.0689 *0.00*	-1.1759 *0.01*	-1.0508 *0.00*
d(log(VEHP))							
d(NEWVEHQPC)	4.2285 *0.18*	4.2447 *0.18*	**4.2268** ***0.17***	**7.4746** ***0.09***	5.3876 *0.08*	6.3518 *0.09*	5.2809 *0.08*
d(AGGDP%)	0.3910 *0.92*	0.4421 *0.91*	**0.5307** ***0.89***	**-0.3668** ***0.94***	1.9274 *0.66*	0.2394 *0.96*	2.4700 *0.56*
d(UNEMP%)	0.0021 *0.96*	0.0023 *0.96*	**0.0027** ***0.95***	**0.0155** ***0.75***	-0.0041 *0.93*	-0.0139 *0.78*	-0.0008 *0.98*
QUARTER1	-0.0197 *0.49*	-0.0198 *0.49*	**-0.0200** ***0.48***	**-0.0374** ***0.26***	-0.0153 *0.57*	-0.0105 *0.71*	-0.0169 *0.54*
QUARTER2	0.0267 *0.19*	0.0266 *0.19*	**0.0265** ***0.19***	**0.0299** ***0.10***	0.0372 *0.04*	0.0418 *0.13*	0.0353 *0.06*
QUARTER3	0.0133 *0.59*	0.0134 *0.60*	**0.0137** ***0.57***	**0.0159** ***0.48***	0.0174 *0.49*	0.0081 *0.77*	0.0188 *0.44*
OILSHOCK	0.0099 *0.46*	0.0100 *0.46*	**0.0104** ***0.43***	**0.0134** ***0.33***	0.0102 *0.47*	0.0005 *0.98*	0.0128 *0.35*
FLOOD	-0.1614 *0.00*	-0.1613 *0.00*	**-0.1603** ***0.00***		-0.1793 *0.00*	-0.2126 *0.00*	-0.1723 *0.00*
Adjusted R-squared	0.1809	0.1807	**0.2026**	**0.0543**	0.1094	-0.1349	0.1500
Wald F-Statistic F-Statistic (for IV)	202.161 *0.00*	204.599 *0.00*	**228.556** ***0.00***	**5.1565** ***0.00***	1.7872 *0.08*	1.4096 *0.20*	1.9994 *0.05*
DW-Stat	2.3741	2.3722	**2.3677**	**2.5525**	2.2325	2.1607	2.2250
AIC	-2.8582	-2.8579	**-2.8969**	**-2.7388**			
Instrument Variable					log(OILP)		
Endogeneity Test					*0.13*	*0.13*	*0.14*

Table C35. Time Series Analysis for Bangkok with Quarterly Data, 2003-2015, IV Model 4 and Asymmetric Models 1-4

Bangkok d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables						
	IV4	Asym1	Asym2	Asym3	Asym4		
C	-0.0214 *0.33*	-0.0272 *0.22*	-0.0270 *0.23*	-0.0274 *0.21*	-0.0231 *0.29*		
d(log(GASP))	-0.4915 *0.02*						
d(log(GASPCUT))		-0.3160 *0.04*	-0.3644 *0.12*	-0.2886 *0.04*	-0.1730 *0.31*		
d(log(GASPREC))		-0.0204 *0.95*	-0.0711 *0.85*	-0.0080 *0.98*	0.0249 *0.94*		
d(log(GDP))	0.3371 *0.76*	1.5224 *0.12*	1.5105 *0.13*	1.4568 *0.15*	1.0125 *0.37*		
d(log(DIESELP))	0.4027 *0.08*	0.1887 *0.27*	0.1886 *0.27*	0.1694 *0.26*	0.0941 *0.52*		
D(log(DIESELP)/ log(GASP))							
d(log(LPGP))	0.6491 *0.10*	0.7058 *0.07*	0.6834 *0.06*	0.6211 *0.06*	0.7081 *0.03*		
D(log(LPGP)/ log(GASP))							
d(log(NATGASP))		-0.0911 *0.62*					
D(log(NATGASP)/ log(GASP))			-0.2537 *0.66*				
d(log(TRANSITP))	-1.0626 *0.00*	-0.9764 *0.00*	-0.9793 *0.00*	-0.9706 *0.00*	-0.8825 *0.00*		
d(log(VEHP))							
d(NEWVEHQPC)	9.5145 *0.09*	4.3534 *0.18*	4.4047 *0.17*	4.3428 *0.17*	7.6535 *0.09*		
d(AGGDP%)	2.5757 *0.63*	0.3783 *0.92*	0.4482 *0.91*	0.7198 *0.85*	-0.2603 *0.96*		
d(UNEMP%)	0.0116 *0.79*	-0.0027 *0.95*	-0.0023 *0.96*	-0.0011 *0.98*	0.0133 *0.78*		
QUARTER1	-0.0346 *0.29*	-0.0151 *0.57*	-0.0153 *0.57*	-0.0160 *0.56*	-0.0351 *0.26*		
QUARTER2	0.0441 *0.01*	0.0283 *0.13*	0.0280 *0.13*	0.0277 *0.15*	0.0308 *0.07*		
QUARTER3	0.0242 *0.29*	0.0144 *0.58*	0.0141 *0.60*	0.0152 *0.55*	0.0170 *0.46*		
OILSHOCK	0.0175 *0.23*	0.0111 *0.44*	0.0112 *0.43*	0.0123 *0.37*	0.0148 *0.30*		
FLOOD		-0.1703 *0.00*	-0.1706 *0.00*	-0.1671 *0.00*			
Adjusted R-squared	-0.0700	0.1868	0.1861	0.2070	0.0417		
Wald F-Statistic F-Statistic (for IV)	1.3053 *0.26*	268.470 *0.00*	268.988 *0.00*	301.328 *0.00*	5.2199 *0.00*		

Bangkok d(log(GASQPC))	Coefficient and *P-Value (in italic)* of Independent Variables					
	IV4	Asym1	Asym2	Asym3	Asym4		
DW-Stat	2.4034	2.3434	2.3407	2.3241	2.5196		
AIC		-2.8543	-2.8535	-2.8905	-2.7130		
Instrument Variable	log(OILP)						
Endogeneity Test	*0.05*				#		
Wald Test (H0: GASPCUT =GASPREC)		*0.35*	*0.36*	*0.39*	*0.56*#		

Appendix D

IDENTIFICATION OF PROVINCES IN THE 4 REGIONS

Table D1. Identification of Provinces in the 4 Regions

Province	Southern region (SR)	Northern region (NR)	Central region (CR)	Northeastern region (NE)
1	Krabi	Kamphaengphet	Kanchanaburi	Kalasin
2	Chumphon	Chiangmai	Chanthaburi	Khonkaen
3	Trang	Chiangrai	Chachoengsao	Chaiyaphum
4	Nakhonsi-thammarat	Phetchabun	Chonburi	Nakhonphanom
5	Narathiwat	Phitsanulok	Chainat	Nakhonratchasima
6	Pattani	Phrae	Trat	Buriram
7	Phangnga	Lampang	Nakhonnayok	Buengkan
8	Phatthalung	Lamphun	Nakhonpathom	Mahasarakham
9	Phuket	Sukhothai	Nonthaburi	Yasothon
10	Yala	Uttaradit	Pathumthani	Roiet
11	Ranong	Uthaithani	Prachuapkhirikhan	Loei
12	Songkhla	Tak	Prachinburi	Sisaket
13	Satun	Nakhonsawan	Phetchaburi	Sakonnakhon
14	Suratthani	Nan	Rayong	Surin
15		Phayao	Ratchaburi	Nongkhai
16		Phichit	Lopburi	Nongbualamphu
17		Maehongson	Samutprakan	Udonthani
18			Samutsongkhram	Ubonratchathani
19			Samutsakhon	Amnatchareon
20			Saraburi	Mukdahan
21			Sakaew	
22			Singburi	
23			Suphanburi	
24			Angthong	
25			Phranakhonsri-ayuthaya	

Appendix E

CORRELOGRAMS OF RESIDUALS FROM REGRESSION ANALYSIS

List of Tables in Appendix E

Table E1. Correlogram of Residuals for Simple Model 3 of Southern Region with Annual Data

Sample: 1993 2015
Included observations: 12
Q-statistic probabilities adjusted for 9 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.348	-0.348	1.8509	0.174
		2	-0.252	-0.425	2.9176	0.233
		3	0.331	0.081	4.9624	0.175
		4	-0.308	-0.313	6.9530	0.138
		5	0.184	0.142	7.7628	0.170
		6	-0.076	-0.274	7.9248	0.244
		7	-0.241	-0.205	9.8842	0.195
		8	0.251	-0.228	12.526	0.129
		9	-0.013	-0.001	12.536	0.185
		10	-0.032	-0.042	12.622	0.246
		11	0.005	-0.108	12.627	0.318

*Probabilities may not be valid for this equation specification.

Table E2. Correlogram of Residuals for Simple Model 5 of Southern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 10 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.255	-0.255	3.5161	0.061
		2	-0.154	-0.234	4.8225	0.090
		3	0.330	0.251	10.964	0.012
		4	-0.022	0.124	10.993	0.027
		5	-0.067	0.057	11.257	0.047
		6	0.006	-0.095	11.259	0.081
		7	0.120	0.073	12.145	0.096
		8	-0.130	-0.098	13.215	0.105
		9	0.026	0.032	13.257	0.151
		10	-0.036	-0.135	13.342	0.205
		11	0.049	0.092	13.504	0.262
		12	0.093	0.128	14.107	0.294
		13	-0.126	0.005	15.238	0.293
		14	-0.055	-0.173	15.457	0.348
		15	0.074	-0.059	15.868	0.391
		16	-0.170	-0.217	18.090	0.319
		17	-0.025	-0.008	18.139	0.380
		18	-0.024	-0.143	18.188	0.443
		19	-0.089	-0.033	18.861	0.466
		20	-0.018	-0.036	18.889	0.529
		21	-0.072	-0.027	19.355	0.562
		22	-0.018	-0.091	19.385	0.621
		23	-0.004	-0.021	19.386	0.679
		24	0.078	0.062	19.996	0.697

*Probabilities may not be valid for this equation specification.

Table E3. Correlogram of Residuals for Simple Model 7 of Southern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 13 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.209	-0.209	2.3538	0.125
		2	-0.120	-0.171	3.1446	0.208
		3	0.309	0.263	8.5388	0.036
		4	-0.078	0.030	8.8890	0.064
		5	-0.050	0.005	9.0350	0.108
		6	0.029	-0.079	9.0848	0.169
		7	0.107	0.123	9.7864	0.201
		8	-0.092	-0.043	10.320	0.243
		9	0.038	0.055	10.414	0.318
		10	-0.096	-0.196	11.027	0.355
		11	0.023	0.036	11.062	0.438
		12	0.137	0.119	12.359	0.417
		13	-0.165	-0.029	14.287	0.354
		14	-0.025	-0.121	14.333	0.425
		15	0.121	0.033	15.439	0.420
		16	-0.252	-0.216	20.324	0.206
		17	0.005	0.027	20.326	0.258
		18	-0.030	-0.199	20.401	0.311
		19	-0.096	-0.019	21.176	0.327
		20	0.016	-0.041	21.199	0.385
		21	-0.111	-0.058	22.304	0.382
		22	-0.026	-0.091	22.367	0.438
		23	0.001	0.013	22.367	0.498
		24	0.060	0.045	22.732	0.536

*Probabilities may not be valid for this equation specification.

Table E4. Correlogram of Residuals for Simple Model 3 of Northern Region with Annual Data

Sample: 1993 2015
Included observations: 12
Q-statistic probabilities adjusted for 8 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.532	-0.532	4.3146	0.038
		2	0.093	-0.264	4.4602	0.108
		3	-0.049	-0.190	4.5055	0.212
		4	0.160	0.093	5.0456	0.283
		5	-0.325	-0.263	7.5730	0.181
		6	0.276	-0.041	9.7093	0.137
		7	-0.077	0.039	9.9088	0.194
		8	-0.031	-0.045	9.9491	0.269
		9	0.013	0.022	9.9584	0.354
		10	-0.027	-0.159	10.022	0.439
		11	-0.002	-0.054	10.022	0.528

*Probabilities may not be valid for this equation specification.

Table E5. Correlogram of Residuals for Simple Model 4 of Northern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 11 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.163	-0.163	1.4282	0.232
		2	-0.436	-0.475	11.910	0.003
		3	0.011	-0.227	11.917	0.008
		4	0.148	-0.161	13.181	0.010
		5	0.026	-0.085	13.222	0.021
		6	-0.084	-0.107	13.650	0.034
		7	0.115	0.121	14.465	0.044
		8	-0.171	-0.214	16.307	0.038
		9	-0.009	-0.028	16.312	0.061
		10	0.041	-0.195	16.422	0.088
		11	0.212	0.203	19.453	0.053
		12	-0.232	-0.289	23.197	0.026
		13	-0.175	-0.089	25.367	0.021
		14	0.261	-0.105	30.328	0.007
		15	0.086	0.070	30.886	0.009
		16	-0.079	-0.060	31.363	0.012
		17	-0.140	0.021	32.929	0.012
		18	0.064	-0.157	33.262	0.016
		19	-0.030	-0.044	33.337	0.022
		20	0.033	-0.191	33.431	0.030
		21	0.041	-0.056	33.584	0.040
		22	0.115	0.097	34.816	0.040
		23	-0.070	0.135	35.283	0.049
		24	-0.178	-0.041	38.442	0.031

*Probabilities may not be valid for this equation specification.

Table E6. Correlogram of Residuals for Simple Model 7 of Northern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 12 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.162	-0.162	1.4156	0.234
		2	-0.356	-0.393	8.4212	0.015
		3	-0.008	-0.184	8.4247	0.038
		4	0.136	-0.064	9.4941	0.050
		5	0.028	-0.021	9.5386	0.089
		6	-0.133	-0.114	10.597	0.102
		7	0.102	0.085	11.241	0.128
		8	-0.212	-0.310	14.071	0.080
		9	-0.007	-0.121	14.074	0.120
		10	0.055	-0.217	14.270	0.161
		11	0.269	0.225	19.150	0.058
		12	-0.188	-0.170	21.589	0.042
		13	-0.273	-0.168	26.887	0.013
		14	0.244	-0.056	31.246	0.005
		15	0.084	-0.061	31.776	0.007
		16	-0.045	-0.102	31.931	0.010
		17	-0.103	-0.028	32.778	0.012
		18	0.093	-0.061	33.489	0.015
		19	-0.033	-0.011	33.581	0.021
		20	-0.030	-0.097	33.659	0.029
		21	0.071	-0.079	34.109	0.035
		22	0.113	0.114	35.291	0.036
		23	-0.087	0.032	36.023	0.041
		24	-0.145	0.036	38.133	0.034

*Probabilities may not be valid for this equation specification.

Table E7. Correlogram of Residuals for Asymmetric Model 7 of Northern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 13 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.172	-0.172	1.5951	0.207
		2	-0.290	-0.329	6.2275	0.044
		3	0.008	-0.133	6.2309	0.101
		4	0.142	0.020	7.3856	0.117
		5	-0.030	-0.026	7.4380	0.190
		6	-0.178	-0.160	9.3494	0.155
		7	0.244	0.193	13.009	0.072
		8	-0.262	-0.332	17.334	0.027
		9	0.013	0.022	17.344	0.044
		10	0.059	-0.097	17.571	0.063
		11	0.225	0.243	20.995	0.033
		12	-0.163	-0.126	22.830	0.029
		13	-0.241	-0.095	26.966	0.013
		14	0.175	-0.132	29.192	0.010
		15	0.046	0.074	29.353	0.014
		16	-0.019	-0.135	29.380	0.021
		17	-0.093	0.099	30.072	0.026
		18	0.105	-0.117	30.979	0.029
		19	-0.087	0.043	31.612	0.035
		20	-0.071	-0.210	32.047	0.043
		21	0.022	-0.110	32.089	0.057
		22	0.144	0.032	34.013	0.049
		23	-0.089	-0.018	34.772	0.055
		24	-0.141	-0.087	36.762	0.046

*Probabilities may not be valid for this equation specification.

Table E8. Correlogram of Residuals for Simple Model 3 of Central Region with Annual Data

Sample: 1993 2015
Included observations: 12
Q-statistic probabilities adjusted for 8 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.030	0.030	0.0140	0.906
		2	-0.077	-0.078	0.1143	0.944
		3	-0.044	-0.039	0.1503	0.985
		4	-0.093	-0.098	0.3335	0.988
		5	-0.403	-0.411	4.2286	0.517
		6	-0.195	-0.254	5.2939	0.507
		7	0.197	0.115	6.6034	0.471
		8	-0.017	-0.124	6.6154	0.579
		9	0.051	-0.052	6.7613	0.662
		10	0.059	-0.180	7.0538	0.720
		11	-0.008	-0.239	7.0654	0.794

*Probabilities may not be valid for this equation specification.

Table E9. Correlogram of Residuals for Simple Model 4 of Central Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 10 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.237	-0.237	3.0277	0.082
		2	-0.187	-0.257	4.9578	0.084
		3	0.041	-0.085	5.0536	0.168
		4	-0.046	-0.121	5.1765	0.270
		5	-0.036	-0.104	5.2514	0.386
		6	0.101	0.031	5.8627	0.439
		7	-0.041	-0.035	5.9660	0.544
		8	-0.018	-0.014	5.9860	0.649
		9	-0.083	-0.127	6.4270	0.697
		10	0.040	-0.031	6.5333	0.769
		11	-0.048	-0.111	6.6891	0.824
		12	-0.051	-0.137	6.8670	0.866
		13	0.036	-0.085	6.9597	0.904
		14	0.016	-0.068	6.9778	0.936
		15	0.139	0.140	8.4297	0.905
		16	-0.065	-0.007	8.7536	0.923
		17	0.034	0.107	8.8473	0.945
		18	-0.037	-0.008	8.9606	0.961
		19	-0.054	-0.038	9.2034	0.970
		20	0.041	-0.017	9.3518	0.978
		21	0.169	0.146	11.910	0.942
		22	-0.173	-0.063	14.707	0.875
		23	0.188	0.241	18.103	0.752
		24	-0.183	-0.085	21.441	0.613

*Probabilities may not be valid for this equation specification.

Table E10. Correlogram of Residuals for Simple Model 7 of Central Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 11 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.125	-0.125	0.8464	0.358
		2	-0.018	-0.034	0.8634	0.649
		3	-0.040	-0.047	0.9521	0.813
		4	-0.031	-0.043	1.0064	0.909
		5	-0.065	-0.079	1.2553	0.939
		6	0.103	0.082	1.8917	0.929
		7	-0.164	-0.153	3.5485	0.830
		8	-0.101	-0.150	4.1874	0.840
		9	-0.017	-0.062	4.2063	0.897
		10	-0.020	-0.058	4.2340	0.936
		11	-0.051	-0.090	4.4095	0.956
		12	0.105	0.038	5.1732	0.952
		13	-0.063	-0.054	5.4554	0.964
		14	0.001	-0.039	5.4555	0.978
		15	0.125	0.082	6.6220	0.967
		16	-0.042	-0.052	6.7614	0.978
		17	0.147	0.146	8.4762	0.955
		18	-0.069	-0.078	8.8606	0.963
		19	-0.036	-0.026	8.9698	0.974
		20	-0.052	-0.044	9.2050	0.980
		21	0.119	0.085	10.478	0.972
		22	-0.145	-0.094	12.432	0.948
		23	0.221	0.218	17.158	0.801
		24	-0.158	-0.100	19.671	0.715

*Probabilities may not be valid for this equation specification.

Table E11. Correlogram of Residuals for Simple Model 5 of Northeastern Region with Annual Data

Sample: 1993 2015
Included observations: 14
Q-statistic probabilities adjusted for 7 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.379	0.379	2.4744	0.116
		2	-0.072	-0.252	2.5715	0.276
		3	-0.150	-0.025	3.0299	0.387
		4	-0.092	-0.036	3.2186	0.522
		5	-0.438	-0.524	8.0038	0.156
		6	-0.353	0.023	11.490	0.074
		7	0.010	0.055	11.493	0.118
		8	0.111	-0.203	11.954	0.153
		9	0.007	0.027	11.956	0.216
		10	0.010	-0.210	11.962	0.288
		11	0.057	-0.183	12.202	0.349
		12	0.025	0.102	12.274	0.424

*Probabilities may not be valid for this equation specification.

Table E12. Correlogram of Residuals for Simple Model 4 of Northeastern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 59
Q-statistic probabilities adjusted for 9 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.327	-0.327	6.6292	0.010
		2	-0.073	-0.201	6.9667	0.031
		3	0.044	-0.059	7.0931	0.069
		4	0.074	0.066	7.4474	0.114
		5	0.073	0.154	7.8003	0.168
		6	-0.129	-0.029	8.9286	0.178
		7	0.163	0.145	10.769	0.149
		8	-0.058	0.017	11.003	0.202
		9	-0.228	-0.275	14.735	0.098
		10	0.274	0.104	20.234	0.027
		11	-0.082	-0.014	20.733	0.036
		12	-0.091	-0.115	21.364	0.045
		13	-0.086	-0.114	21.937	0.056
		14	0.035	-0.091	22.033	0.078
		15	0.079	-0.005	22.538	0.094
		16	-0.197	-0.078	25.782	0.057
		17	0.045	-0.085	25.956	0.075
		18	-0.021	-0.091	25.997	0.100
		19	-0.129	-0.121	27.495	0.094
		20	0.072	-0.067	27.971	0.110
		21	0.020	0.006	28.008	0.140
		22	0.073	0.112	28.524	0.159
		23	-0.185	-0.058	31.952	0.101
		24	0.054	-0.019	32.255	0.121

*Probabilities may not be valid for this equation specification.

Table E13. Correlogram of Residuals for Simple Model 7 of Northeastern Region with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 11 dynamic regressors

	AC	PAC	Q-Stat	Prob*
1	-0.296	-0.296	4.7439	0.029
2	0.013	-0.082	4.7536	0.093
3	0.024	0.005	4.7871	0.188
4	-0.014	-0.004	4.7982	0.309
5	0.129	0.138	5.7748	0.329
6	-0.181	-0.114	7.7466	0.257
7	0.143	0.070	8.9948	0.253
8	0.003	0.055	8.9952	0.343
9	-0.105	-0.089	9.7115	0.374
10	0.193	0.145	12.175	0.274
11	0.061	0.205	12.426	0.332
12	-0.096	-0.065	13.069	0.364
13	-0.223	-0.301	16.616	0.217
14	0.061	-0.111	16.888	0.262
15	0.044	-0.037	17.032	0.317
16	-0.179	-0.165	19.501	0.244
17	0.031	-0.039	19.579	0.296
18	-0.055	-0.087	19.831	0.342
19	0.001	-0.091	19.831	0.405
20	-0.184	-0.244	22.794	0.299
21	0.077	-0.082	23.329	0.327
22	0.062	0.045	23.690	0.364
23	-0.186	0.013	27.034	0.255
24	-0.022	-0.035	27.084	0.301

*Probabilities may not be valid for this equation specification.

Table E14. Correlogram of Residuals for Simple Model 3 of Bangkok with Annual Data

Sample: 1993 2015
Included observations: 12
Q-statistic probabilities adjusted for 8 dynamic regressors

	AC	PAC	Q-Stat	Prob*
1	-0.438	-0.438	2.9362	0.087
2	0.050	-0.176	2.9788	0.226
3	-0.140	-0.244	3.3425	0.342
4	0.233	0.086	4.4796	0.345
5	-0.034	0.137	4.5068	0.479
6	-0.197	-0.178	5.5960	0.470
7	0.164	0.046	6.4967	0.483
8	-0.167	-0.183	7.6734	0.466
9	0.189	0.009	9.6819	0.377
10	-0.136	0.043	11.230	0.340
11	-0.024	-0.155	11.327	0.416

*Probabilities may not be valid for this equation specification.

Table E15. Correlogram of Residuals for Simple Model 7 of Bangkok with Annual Data

Sample: 1993 2015
Included observations: 12
Q-statistic probabilities adjusted for 8 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	0.200	0.200	0.6134	0.434
		2	0.184	0.150	1.1838	0.553
		3	-0.245	-0.327	2.3063	0.511
		4	-0.131	-0.060	2.6687	0.615
		5	-0.401	-0.301	6.5190	0.259
		6	-0.231	-0.188	8.0112	0.237
		7	-0.149	-0.022	8.7533	0.271
		8	0.090	-0.009	9.0928	0.335
		9	0.092	-0.051	9.5703	0.386
		10	0.064	-0.174	9.9185	0.448
		11	0.025	-0.120	10.026	0.528

*Probabilities may not be valid for this equation specification.

Table E16. Correlogram of Residuals for Simple Model 3 of Bangkok with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 13 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.194	-0.194	2.0421	0.153
		2	-0.125	-0.170	2.9086	0.234
		3	-0.012	-0.078	2.9163	0.405
		4	0.067	0.028	3.1761	0.529
		5	-0.059	-0.052	3.3783	0.642
		6	-0.039	-0.054	3.4707	0.748
		7	-0.108	-0.153	4.1935	0.757
		8	-0.287	-0.408	9.3693	0.312
		9	0.140	-0.113	10.628	0.302
		10	0.087	-0.041	11.123	0.348
		11	0.077	0.100	11.527	0.400
		12	-0.209	-0.181	14.547	0.267
		13	0.119	-0.056	15.550	0.274
		14	0.155	0.045	17.304	0.240
		15	-0.071	-0.149	17.677	0.280
		16	0.091	0.029	18.314	0.306
		17	-0.158	-0.152	20.298	0.259
		18	-0.030	-0.086	20.373	0.312
		19	-0.064	-0.174	20.723	0.352
		20	0.011	-0.292	20.733	0.413
		21	0.133	0.157	22.328	0.381
		22	-0.005	0.103	22.330	0.440
		23	-0.082	-0.080	22.972	0.462
		24	-0.010	-0.192	22.982	0.521

*Probabilities may not be valid for this equation specification.

Table E17. Correlogram of Residuals for Simple Model 4 of Bangkok with Quarterly Data

Sample: 1993Q1 2015Q4
Included observations: 51
Q-statistic probabilities adjusted for 12 dynamic regressors

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob*
		1	-0.282	-0.282	4.2904	0.038
		2	-0.060	-0.151	4.4889	0.106
		3	0.113	0.056	5.2051	0.157
		4	-0.041	0.003	5.3008	0.258
		5	-0.103	-0.107	5.9199	0.314
		6	-0.033	-0.121	5.9858	0.425
		7	-0.031	-0.104	6.0441	0.535
		8	-0.193	-0.262	8.3809	0.397
		9	0.084	-0.084	8.8315	0.453
		10	-0.015	-0.082	8.8472	0.547
		11	0.066	0.051	9.1426	0.609
		12	-0.170	-0.230	11.157	0.516
		13	0.115	-0.093	12.093	0.520
		14	0.139	0.059	13.510	0.487
		15	-0.059	0.008	13.771	0.543
		16	0.172	0.162	16.056	0.449
		17	-0.109	-0.060	17.002	0.454
		18	0.027	0.002	17.064	0.519
		19	-0.048	-0.062	17.258	0.572
		20	-0.067	-0.147	17.651	0.610
		21	-0.010	0.002	17.660	0.670
		22	0.095	0.186	18.504	0.676
		23	-0.142	-0.021	20.461	0.614
		24	-0.149	-0.287	22.680	0.539

*Probabilities may not be valid for this equation specification.