The Strategies Reducing the Negative Externalities of Semi-trailer Truck Transportation in Eastern Economic Corridor Area

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Abstract

The rising demand for sea-container transportation in most developing countries escalates the number of semi-trailer trucks (STTs) on the road resulting in air pollution, road accident, and traffic congestion. To address these negative externalities, this study originally identified a set of traffic control strategies and adopted the ordered logit model to analyze its effectiveness in reducing the STTs' externalities in Laem Chabang municipality where many large seaports are located. The existing literature was used as the reference to generate the relevant attributions used to develop a questionnaire survey randomly distributed to the respondents in five communities. Based on 414 responses, the immediate lane changing was ranked the first, followed by the violation of speed limit, and the unsafe parking, while the defect of vehicle, support equipment, and coupling device was ranked in the top five potential causes of STTs' externalities. The ordered logit model revealed that the non-engineering strategies, especially legal enforcement and driving skill improvement, had a larger impact on the reduction of negative externalities caused by both drivers and their vehicles, while the engineering strategies, such as rumble strips, and automatic speed camera, tended to reduce only the driver-generated externalities.

Keywords: Strategies, negative externalities, semi-trailer trucks, Eastern Economic Corridor, Laem Chabang municipality, ordered logit model

Introduction

Logistically, container transportation by a semi-trailer truck (STT-the combination of a tractor unit and one or more semi-trailers to carry container boxes) is an irreplaceable part in logistics and supply chain management. Due to its competitive advantages, the STT has become the popular vehicle for connecting seaports and the hinterland in Southeast Asia (Yap, 2013). Annually, the number of STTs on urban and interurban roads in some ASEAN countries (Thailand, Malaysia, the Philippines, Vietnam, and Cambodia) continuously increases because of the rising throughputs of the major seaports (Yap, 2013). The situation worsened when the overwhelming use of containers excess to port capacities required the excess containers to be brought by STTs from the in-dock facilities of seaports to off-dock storage yards, which mostly are located around the local communities (Davies, 2006; IBI Group, 2006). This phenomenon directly affects the local road users and residents, especially those living in the major seaport areas, such as the Port of Klang (Yap, 2013), Vancouver Port (Davies, 2006), the Port of Rotterdam (Zain, Rahman, Saibani, Nopiah, Ramli, & Jusoh, 2015), the Ports of New York (IBI Group, 2006), ports in Spain (Laxe, Bermúdez, Palmero, & Novo-Corti, 2016), ports in the UK (Asgari, Hassani, Jones & Nguye, 2015), and ports in Japan (Motono, Kimito, Furuichi & Suzuki, 2014), in terms of road accidents, chronic stress from traffic congestion, and health problems from traffic pollution emissions (World Health Organization, 2015).

Likewise, in Thailand, road-transport infrastructure annually supports almost 90% of the domestic freight transport, which is mostly carried by STTs (Thailand Board of Investment, 2016). Recently, the number of STTs substantially increased because of the emerging demand for sea transport of imported and exported containers by the new industries in Eastern Economic Corridor (EEC) areas that cover three industrial provinces (Chachoengsao, Rayong, and Chonburi). In Laem Chabang municipality (LCM), Chonburi for example, more than 20,000 TEUs are distributed daily among the Laem Chabang Port (the largest container port on the eastern coast of Thailand), 15 industrial estates in Chonburi (approximately 26% of the total industrial estates in Thailand), and more than 1,000 factories throughout the country (Industrial Estate Authority of Thailand, 2015). The number of truck companies registered by the Department of Land Transport increased from 45,855 in 2008 to 77,751 in 2015, while in the same period the number of STTs rose from 105,593 to 187,219 (Department of Land Transport, 2015), as shown in Figure 1. As expected, the rate of STT-related accidents has continued to grow in LCM, with the death rate of local vehicle users increasing from 1,961 in 2014 to 2,020 in 2015 (Royal Thai Police, 2015), as shown in Figure 1. The increasing rate of deaths and injuries in the port-proximate communities of Thailand and other countries indicates the negative externalities caused by STT transport (Kumar and Anbanandam, 2019) and highlights the inevitable obligation of modern-truck operators and policy makers to secure community sustainability (United Nations, 2017), including the preservation of communities against the negative externalities from STT transport (World Health Organization, 2016). To do so, there needs to be scientific research showing how STTs' negative externalities can be reduced. Unfortunately, a review of relevant literature from 1987 to 2018 showed scarce scholastic effort to take this issue into account, while the topics of economic and environmental sustainability of seaports, and truck-transportation operation have drawn a great of attention from scholars worldwide.

Hence, this study addressed the scarcity of the literature by 1) originally identifying the potential traffic control strategies (TCSs) for reducing the negative externalities from STT transportation: and 2) analyzing how each TCS selected from the literature could reduce the STTs' negative externalities. The data used in an analysis was obtained from the case of LCM, consisting of Ban Ao Udom, Ban Khao Numsub, Ban Sak Yai Chin, Wat Manorom, and Huai Lek. The criteria for selecting the study areas were: 1) communities were located in the busy freight-transportation areas of the largest port of Thailand; 2) the residents of these communities were likely to be affected by STT transportation due to the increasing number of deaths and injuries; 3) the negative externalities of STT transportation have been continuously increasing due to the development of Laem Chabang Port and other industries under the EEC project (one of the largest national projects supporting the growth of Thailand Economy 4.0); and 4) the selected communities had common problems and situations experienced by many ASEAN and other ports and communities. Therefore, the research findings can provide useful information for local authorities, operators and scholars not only in Thailand, but also in other countries. The remainder of this paper is separated into five major parts; literature review, research methodology, results and discussion, conclusion, and implications.

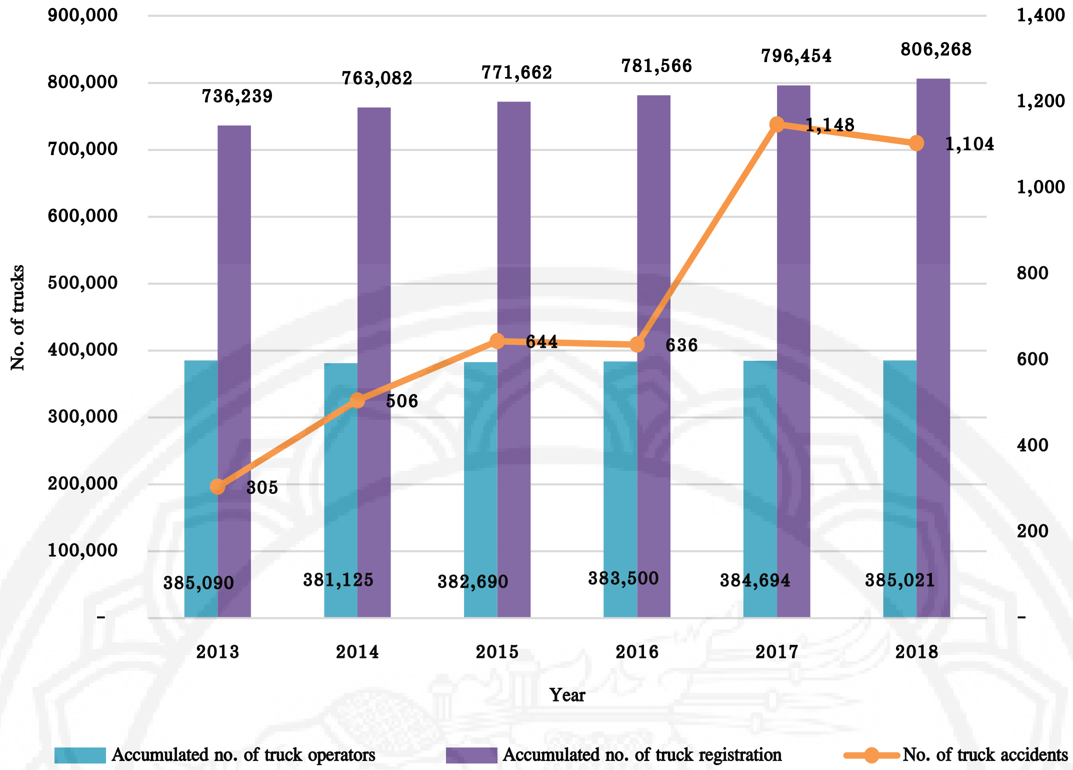

Figure 1 Registration of trucks and truck operators and the number of truck-generated accidents

Source: Department of Land Transport (2015) and Royal Thai Police (2015)

Literature Review

1. Sustainability and STTs' negative externalities

Over decades, natural resources and ecosystems have been continuously degraded by uneven exploitation for the large scale of production in worldwide industries. Consequently, many environmental problems (including climate change due to the GHG emission) and natural disasters occurred frequently, which increased the deaths and the economic losses in many countries. Eventually, in 1928, sustainable development (SD) was discussed in the World Charter for Nature, which mainly focused on ecology (United Nations, 1982). Five years later, the SD concept was amplified in the Brundtland Report which clarified it as the economic development that meets the needs of the present generation without compromising the ability of future generations (Brundtland, 1987). Since then, this concept has been used as the conceptual basis for policy makers in balancing economic and environmental interests in national and local development policy. However, the economic activities and environmental problems were mainly made by humans and in return, the problems degraded society in terms of poverty and man-made hazards. Therefore, the new concept of SD was developed to cover social discipline (Lu, Geng, Liu, Cote, & Yu, 2017). As a result, the sustainability concept covered three main dimensions (i.e. economic, environmental, and social or the triple bottom line), and each dimension is diversified into several themes and sub-goals that need to be accomplished by different stakeholders at all levels, consisting of the government, business, and other entities that coordinate, identify, and manage their positive and negative impacts on employees, workers, customers, people, and local communities (Lu et al., 2017). In 2030 Agenda, the

Sustainable Development Goals (SDGs), comprising 17 goals, were developed and adopted by 193 countries at the UN SD Summit with the purpose of bringing sustainability to the world. Each goal has its sub targets that are the responsibility of different stakeholders depending on national policies and practices. For road transportation, the obligations of the carriers, and related authorities are mentioned in Goal 11 of the SDGs, which aims at making cities and human settlements inclusive, safe, resilient, and sustainable. It requires the government and other relevant stakeholders to make sure that: 1) citizen in all communities have access to safe transport systems and road safety is satisfactory, 2) people in the community should be protected in vulnerable situations and the number of deaths from hazards should be significantly reduced, and 3) the adverse environmental impacts of the cities, especially air pollution, should be reduced (United Nations , 2015).

The current study adopted the notions above as the baseline for developing the assumption that all truck operators and policy makers were supposed to reduce the negative externalities of STT transportation, as explained in Table 1, on the sustainability of communities through the implementation of effective TCSs. Unfortunately, no study has identified the potential TCSs for reducing STTs' negative externalities. Many studies reported the increasing tendency of environmental problems and road accidents from freight transportation, such as Elvik, Christensen, and Amundsen (2004), Leechawengwongs, Leechawengwongs, Sukying, and Udomsubpayakul (2006), European Agency for Safety and Health at Work (2010), European Environment Agency (2011), Duke, Guest, and Boggess (2010), Quezon, Wedajo, and Mohammed (2017), Rys, Judycki, and Jaskula (2017), Kumar and Anbanandam (2019), while various works explored how environmental sustainability could increase the sustainable performance of ports, such as the works of Bridger and Luloff (1999), Eckerberg and Mineur (2003), BSR (2011), Denktas-Sakar and Karatas-Cetin (2012), Asgari et al. (2015), Laxe et al. (2016), Roh, Thai, and Wong (2016), Shi and Li (2016), Sislian, Jaegler, and Cariou (2016), Hedin and Ranängen (2017), Lu et al. (2017), Mapar et al. (2017), Schipper, Vreugdenhil, and Jong (2017), Langenus and Dooms (2018), Morris, Zuo, Wang, and Wang (2018). To narrow the gap in the existing literature, therefore, this study collected the potential TCSs for reducing the negative externalities from STT transportation from the literature survey in the field of road safety and traffic management which was explained in the following section.

Table 1 STTs' negative externalities

Indicator	Description
Road traffic accident	Accidents from STT are in form of sideswipe, head-on collision, driving out of lane, jackknife, rollover, rear end collision, underside accident, and bridge collision, which generate the adverse impacts on the death and injury of STT drivers and other vehicle users.
Property damage	STTs could cause damage to public property, company property, and other private property. Public property refers to any type of assets dedicated to public use and damaged by STTs, such as public road, bridge, electricity post, traffic sign, signal and road marking. The company property means vehicles, cell phone, cargo, transport and handling equipment, and other assets that are owned by the firms. The personal property is any assets that an individual owns, containing car, motorcycle, bike, house, house fence, and cell phone.

Table 1 (Cont.)

Indicator	Description
Traffic congestion	Traffic congestion occurs when the traffic reaches maximum road capacity resulting in the worse quality of life, public health and safety. Driving during a traffic jam can lead to higher chronic stress, lower fitness levels, and higher blood pressure, making people vulnerable to other diseases, distraction, fatigue, and aggressive driving.
Air pollution	STTs potentially cause toxic-gas emissions and making the drivers' exposure to toxic gas which adversely affect the lungs and heart and aggravate heart disease and some types of cancer. Air pollution also doubles the health risk of motorcyclists and pedestrians because they are directly exposed to the toxic gas without any air filter.

Source: World Health Organization (2015)

2. Traffic control strategies for road safety

Road accidents are one of the most important causes of deaths in Thailand; thus, the Department of Land Transport in collaboration with the Department of Highways, the Department of Rural Roads, and the Royal Thai Police have launched many traffic control strategies (TCS) to control the dangers on the main traffic routes of Thailand, while a few of TCS have been executed in small local communities despite the fact that some communities have an intense freight traffic movements in residential areas. For example, five TCS consisting of speed signs, traffic lights, longitudinal pavement markings, community access restriction measures and law enforcement, are used to control the dangers of a number of STTs in LCM (Sang-uthai, 2017). While the number of deaths and injuries from STT-related accidents in LCM has continued to grow, the implementation of these five TCS has remained that same. The present study assisted LCM and the governmental authorities by measuring the effectiveness of each of the TCSs that are currently implemented in the five communities comprising Ban Ao Udom, Ban Khao Numsub, Ban Sak Yai Chin, Wat Manorom, and Huai Lek, and estimating the probability of success in implementing new TCSs to reduce the dangers. Eight TCSs currently used in Thailand were drawn from the works of (Kanitpong, Jiwattanakulpaisarn, & Yaktawong, 2013) and new five TCSs selected from the works of (Kuiken and Twisk, 2001; Leechawengwongs et al., 2006; Verma and Singh, 2015; Sang-uthai, 2017) were also added to the set of TCSs which was reviewed by a group of experts during the stage of questionnaire development. The TCSs were classified into two main groups (engineering and non-engineering strategies) based on the classification in the study of (Kanitpong et al., 2013). The former group refers to any devices that are built using an engineering-based design for controlling or slowing traffic (rumble strips or speed humps, radar speed gun, traffic lights or signals, automatic speed camera, speed warning or speed limit signs, road maintenance, and lane widening). In contrast, the latter group refers to the adoption of knowledge-based management to control the traffic, such as police checkpoint, incentive program, community access restriction, legal enforcement, and driving skill improvement. All TCSs analyzed in this study are described in Table 2.

Table 2 Potential TCSs obtained from experts' evaluation

Traffic control strategy	Code	Description
Rumble strips or speed humps (ES)	TCS1	Installation of rumble strips to alert careless drivers of dangerous conditions ahead by creating noise and vibration from tires passing over the strips, which then are transmitted through the wheels into the passenger compartment. The installation of speed humps aims at slowing drivers down and increasing

Table 2 (Cont.)

Traffic control strategy	Code	Description

Traffic control strategy	Code	Description
		driver awareness. These two strategies are widely implemented in many parts of Thailand because of their ease of installation and low cost.
Police checkpoint (NES)	TCS2	Setting up a police checkpoint in community to abate the number of risky situations or adverse truck driving behavior (driving with a blood-alcohol level above the legal limit, driving without a license, driving with overloaded cargo, or driving over the maximum speed allowed by local government) that lead to traffic accidents.
Incentive program (NES)	TCS3	The formal schemes that trucking companies use to promote and urge safety performance of STT drivers. The safety objective and desirable rewards of the programs aim at increasing drivers' awareness and safety culture.
Community access restriction (NES)	TCS4	Setting up restriction measures for particular routes and times to limit, allow, or deny access of freight vehicles to the target community area in order to reduce the number of traffic accidents. These measures are being implemented on 9 traffic routes in the LCB Port area.
Radar speed gun (ES)	TCS5	A radar speed gun is used to measure the speed by directing a radio signal towards the moving vehicle and recording the same signal rebounding from the vehicle. The speed is calculated based on changes in the value of the returning signal. This device is popularly used for speed limit enforcement by Thai traffic police.
Traffic lights or signals (ES)	TCS6	Installation of traffic lights or signals at junctions or other places where roads meet in community in order to control the traffic by signaling the drivers (red means stop, green means go, and yellow means slow down).
Automatic speed camera (ES)	TCS7	Installation of automatic speed cameras at crossroads or other dangerous points to control the speed of freight vehicles passing through communities. The camera detects the speed of vehicles using detectors embedded into the road surface or radar technology. If the maximum speed limit is exceeded, the offending vehicles will be automatically caught on the camera and a follow up fine mailed to the registered owner of the vehicle.
Road maintenance (ES)	TCS8	Maintaining the road surface of the traffic lanes to: 1) conserve the road surface in its originally constructed condition, 2) efficiently facilitate travel along the route, 3) reduce risks of road accidents, and 4) decrease the deterioration rate of the road surface from climatic and vehicle use effects.
Lane widening (ES)	TCS9	Expansion of traffic lanes on a straight section, a bend, or a turn lane to reduce the risks of sideswipe crashes and head-on crashes between freight vehicles and other vehicles.
Speed warning or speed limit signs (ES)	TCS10	Installation of speed warning to forewarn the drivers to reduce speed of their freight vehicles or to inform the drivers to drive with caution due to the danger of upcoming road conditions and traffic.
Legal enforcement (NES)	TCS11	An increase in legal enforcement (punishment and fines) on drivers and operators, who violate, ignore, or do not comply with the Thai regulations, such as the Road Traffic Act B.E. 2522 and Transport Act B.E. 2522.
Driving skill improvement (NES)	TCS12	Knowledge and driving-skill training courses that employers use for self-employed truck drivers or staff that drive as part of their job, with the course4s aimed at reducing the risks their staff face and create when driving during working hours. The training courses may cover the topics or skills required by road safety laws for validating their driving license or that are needed to meet safety-related standards for being a professional truck driver.
Protection of mental and physical heath (NES)	TCS13	The implementation of measures to ensure that the mental health (depression, chronic loneliness, anxiety, and chronic sleep disturbance) or physical heath (obesity and physical injuries) of truck drivers are normal. These measures involve providing medical examinations for potential truck drivers, developing good relationships between employers and drivers, creating a comfortable environment at work, and avoiding driver fatigue due to long haulage periods.

Remark: ES =engineering strategy, NES =non-engineering strategy

3. STTs in Laem Chabang municipality

Laem Chabang municipality (LCM) comprises 23 communities locating in Chonburi – the target province of EEC project which is the production base for 3,786 factories in 15 industrial estates (Thailand Board of Investment, 2016). LCM has long coastline in which is the great place for the establishment of many important ports, such as Laem Chabang Port (LCP), SIAMCSP Seaport, Kerry Siam Seaport, Sriracha Harbor Port, PTT Sriracha Oil Terminal, and the Thai Oil Terminal. Every year, approximately 8 million containers are distributed by STTs from ports to the hinterland (United Nations Conference on Trade and Development, 2018). Daily, 21,918 STTs on average navigate the roads in the communities located in LCM, including the Ban Ao Udom, Ban Khao Numsub, Ban Sak Yai Chin, Wat Manorom, and Huai Lek communities, and cause negative externalities, comprising the road accident, traffic congestion, air pollution, and property damage, to 19,453 residents (Jongmeewasin, 2016). The death rate in STT-related accidents in LCM grows from 1,961 deaths in 2014 to 2,020 deaths in 2015 (Royal Thai Police, 2015). The current study identified 11 causes of negative externalities based on the reports of Royal Thai Police (2015) and sorted them into 2 main groups: 1) causes from STT drivers; and 2) causes from STTs, as described in Table 3.

Table 3 Causes of STTs' negative externalities

Cause	Code	Explanation
Violation of speed limit	RD1	The driver exceeds the maximum speed imposed by government agencies for a particular area (45 km/h truck speed limit in Laem Chabang Municipality area). This violation maybe caused intentionally or unintentionally by the driver during the day or at night.
Immediate lane changing	RD2	The driver immediately shifts or switches lanes without giving a turning signal (light or by hand) to warn the other road users.
Truck driver losing control	RD3	The driver cannot control the truck in a safe manner while passing through a community (overshooting or undercutting at crossroads or T-junctions). The loss of control may be caused by mechanical failure, physical disabilities, and mental illness.
Unsafe parking	RD4	Unreasonable parking or stopping of vehicle on the shoulder or in a safety zone, truck stop, or other parts of the road due to illogical reasons, such as taking a short nap, washing vehicle, or buying items from roadside shops.
Truck driver drowsiness and fatigue	RD5	The driver feels sleepy or exhausted while driving during the day or at night due to sleep deprivation from long-haul truck driving.
Carelessness for pedestrians at crosswalk	RD6	The driver does not stop the vehicle at pedestrian crossings and runs pedestrians at crosswalk, 3-way junctions, or other parts of the street in the community.
Inexperienced or new truck driver	RD7	Driving by an inexperienced driver, or a driver with little experience or no training on how to drive safely or on driving-related regulations and laws. This includes hiring a driver with a bad driving record, or hiring a driver who has violated important regulations.
Defected vehicle or driving support devices	RV1	The vehicle configuration (wheels, tires, engine, axles, and wheel bearings) is defective, while broken driving support devices include lights, turn signals, tail lights, and side-view mirrors that cannot be used during driving.
Defected coupling device	RV2	The coupling devices (pin, jaw, hook, or ball) used to couple a semitrailer to the rear of a tractor are deformed, damaged, cracked, and worn because the thickness of metal at

Table 3 (Cont.)

Cause	Code	Explanation
		any point is reduced to less than its original thickness and there is a trailer attached.
Unlocked twistlocks	RV3	The device (twistlock) that prevents the moving or falling of a container from the trailer is not locked into the corners of the container by the driver.
Truck overloading	RV4	Vehicle or a container is overloaded with goods which violates weight limitation regulations that do not allow the total loaded weight of STT to be greater than 21,727 kg for a 20 foot standard container or no more than 26,780 kgs for a 40 foot container.

Remark: RD means STT-driver-generated causes and RV means STT-generated causes.

Research methodology

1. Research method

The study started with a literature review of local and international studies and documents to: 1) identify the research problems and gaps, 2) determine research objectives/questions/hypotheses, and 3) conceptualize the research framework. Following this, a questionnaire was developed and then used to conduct a roadside survey in the five communities by the author. Each questionnaire was gathered and its reliability was tested using the SPSS software package before the data were analyzed using the ordered logit model. Finally, the research findings were summarized and theoretical implications were made for scholars, policy makers, and other practitioners.

2. Study sample and sampling technique

The communities in LCM were purposively selected because the many communities, including Ban Ao Udom, Ban Khao Numsub, Ban Sak Yai Chin, Wat Manorom, and Huai Lek, are located in the busy transportation area of the largest seaport of Thailand, and the number of deaths and injuries from road accidents has continuously increased. Additionally, the negative externalities of STTs are expected to increase owning to the growing number of new industries in Chonburi province and other parts of EEC areas. The respondents to the questionnaire were randomly selected based on convenience in the survey. The number of respondents in the survey was calculated using the Taro Yamane formula with a 95% confidence level. With the population of 19,453 residents in the five communities, approximately 392 respondents are the minimum sample size.

3. Development of questionnaire and survey

The questionnaire was organized into four main parts. The first part contained the questions regarding the socio-economic of the respondents. The second part comprised a list of 11 causes of negative externalities of STTs in the five communities. The respondents were asked to rate each cause using a four-point scale (very dangerous = 4, dangerous = 3, almost dangerous = 2, and not dangerous = 1). The third part consisted of a statement asking the respondents to evaluate the existing levels of four negative externalities of the five communities using a four-point scale (very good=4, good=3, decadent=2, and very decadent=1). The forth part contained 13 statements regarding TCSs. The respondents were asked to demonstrate their agreement or disagreement levels towards each of the TCS regarding its effectiveness at reducing the causes of SSTs' negative externalities in communities using a four-point scale (strongly agree=4, agree=3, disagree=2, and strongly disagree=1). Five transport and logistics experts from the Port Authority of Thailand, and educational institutions, including two heads of communities, were asked to investigate the content validity of the questionnaire using the index of item-objective congruence (IOC). The valid questions obtaining an IOC score between 0.67 and 1.00 were maintained, while questions with an IOC score lower than 0.5 were excluded from the questionnaire. Then, 10 local residents were asked to review the ease of questionnaire format and understanding the words used. Some minor changes were made to a few technical words to improve understanding of the questions.

4. Research hypothesis

The main objective of this study was to investigate the impacts of TCSs on the reduction of the causes of SSTs' negative externalities; thus, the null hypothesis (H_0) was written as the TCS has no impact on the reduction of the causes of SSTs' negative externalities, and the alternative hypothesis (H_1) was that the TCS has an impact on the reduction of the causes of SSTs' negative externalities. The author tested this hypothesis by formulating the ordered logit model, while the descriptive statistics was also used to describe the socio-economic information and the attitude of the respondents.

Results and discussion

1. Results from questionnaire survey

The paper-based questionnaires were randomly distributed to 490 residents in their houses, at office buildings, along streets in the communities, at local markets, and at roadside shops from December 2018 to March 2019. The researcher avoided response bias by explaining the research objectives, the importance of the survey, and the expected benefits for communities. Each questionnaire was collected immediately after the respondent had finished the form. Finally, 414 completed questionnaires (84.5%), which was greater than the required sample size of 392, were collected from the respondents. Cronbach's Alpha was used to test the reliability of the questionnaire using SPSS 23. The value of Cronbach's Alpha was 0.715 indicating that the data collected were reliable. Table 4 describes the socio-economic characteristics of the respondents.

Table 4 Socio-economic characteristics and driving-related information of respondents

General information		Frequency	Percentage
Gender	Male	157	37.9
	Female	257	62.1
	Total	414	100
Community	Ban Ao Udom	65	15.7
	Ban Khao Numsub	61	14.7
	Ban Sak Yai Chin	113	27.3
	Wat Manorom	90	21.7
	Huai Lek	85	20.5
	Total	414	100
Age (years)	< 21	142	34.3
	21-30	139	33.4

Table 4 (Cont.)

General information		Frequency	Percentage
	31-40	93	22.4
	> 40	40	9.6
	Total	414	100
Occupation	Student	201	48.6
	Teacher/Lecturer	32	7.7
	General employee	49	11.8
	Government officer	24	5.8
	Private officer	40	9.7
	Unemployed	20	4.8
	Trailer-truck driver	13	3.1
	Other	35	8.5
	Total	414	100
Driving license	Have license	164	39.6
	No license	250	60.4
	Total	414	100
Vehicle type	Driving motorcycle	304	73.4
	Driving car	100	24.2
	Driving truck	10	2.4
	Total	414	100
Driving experience	< 1 year	55	13.3
	1-3 years	89	21.5
	> 3 years	270	65.2
	Total	414	100
Accident experience	None	225	54.3
	One or more	189	45.7
	Total	414	100
Residential status	Temporary	306	73.9
	Permanent	108	26.1
	Total	414	100

2. Causes of negative externalities

Figure 2 shows that 70-98% of the respondents agreed that violation of the speed limit, dangerous lane changing, unsafe parking, defect truck or driving support devices, and a defect coupling device were the main causes of STTs' negative externalities. In addition, 52-62% of the respondents agreed that losing control of the truck and unlocked twist locks were almost dangerous causes of negative externality, whereas 42-53% of the respondents considered that drowsiness and fatigue of drivers, driving by inexperienced or new truck drivers, and truck overloading were not the cause of STTs' negative externalities. Table 5 indicates that immediate lane changing was the most dangerous cause of negative externality, whereas violation of the speed limit was rated second, followed by unsafe parking, defect truck or driving support devices, defect coupling device, and carelessness of truck drivers, respectively.

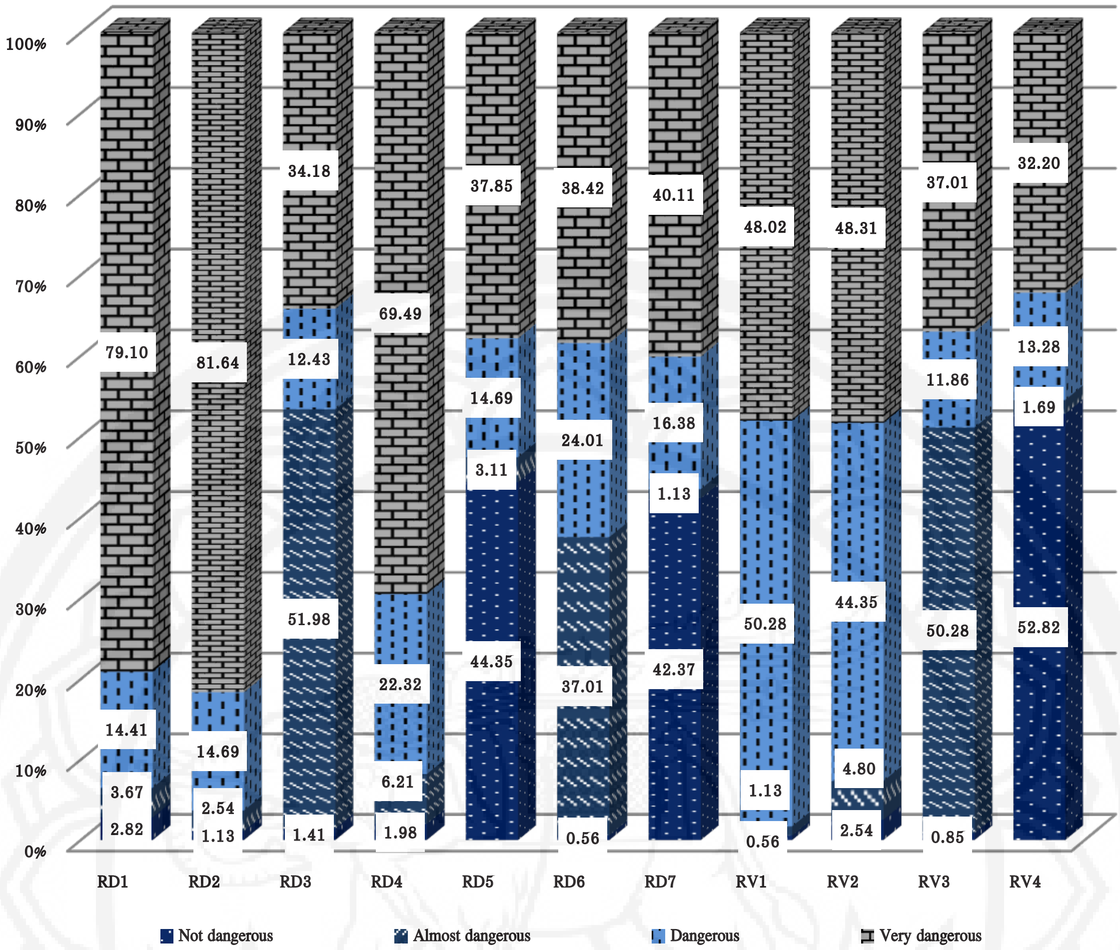

Figure 2 Causes of STTs' negative externalities rated by respondents

Table 5 Rating scores of causes of STTs' negative externalities (n=414)

Danger	Average score	Ranking
Violation of speed limit (RD1)	3.70	2
Immediate lane changing (RD2)	3.77	1
Truck driver losing control (RD3)	2.79	8
Unsafe parking (RD4)	3.59	3
Truck driver drowsiness and fatigue (RD5)	2.46	10
Carelessness regarding pedestrians at crosswalks (RD6)	3.00	6
Inexperienced or new truck driver (RD7)	2.54	9
Defect vehicle or driving support devices (RV1)	3.46	4
Defect coupling device (RV2)	3.38	5
Unlocked twistlocks (RV3)	2.85	7
Truck overloading (RV4)	2.25	11

3. Effects of TCSs on the reduction of negative-externality causes

Based on the 414 responses, the residents' attitudes towards the implementation of 13 TCSs for reducing negative externalities from STT transportation are presented in Figure 3 and Table 6. Figure 3 shows that 83.9% of the respondents strongly agreed that speed warning or speed limit signs are effective TCSs. In addition, 56-67% of the respondents agreed that rumble strips or speed humps, police checkpoint, incentive program, traffic lights or signals, and automatic speed cameras (TCS7) were possible TCSs. In contrast, 53-96% of the respondents identified seven TCSs as ineffective at reducing dangers: community access restriction, radar speed gun, road maintenance, lane widening, legal enforcement, driving skill improvement, and protection of mental and physical heath. Table 8 reflects that speed warning or speed limit signs were the most feasible strategies to address the dangers in the five communities, while rumble strips or speed humps was rated second, followed by police checkpoint (TCS2), traffic lights or signals (TCS6), and incentive program (TCS3), respectively.

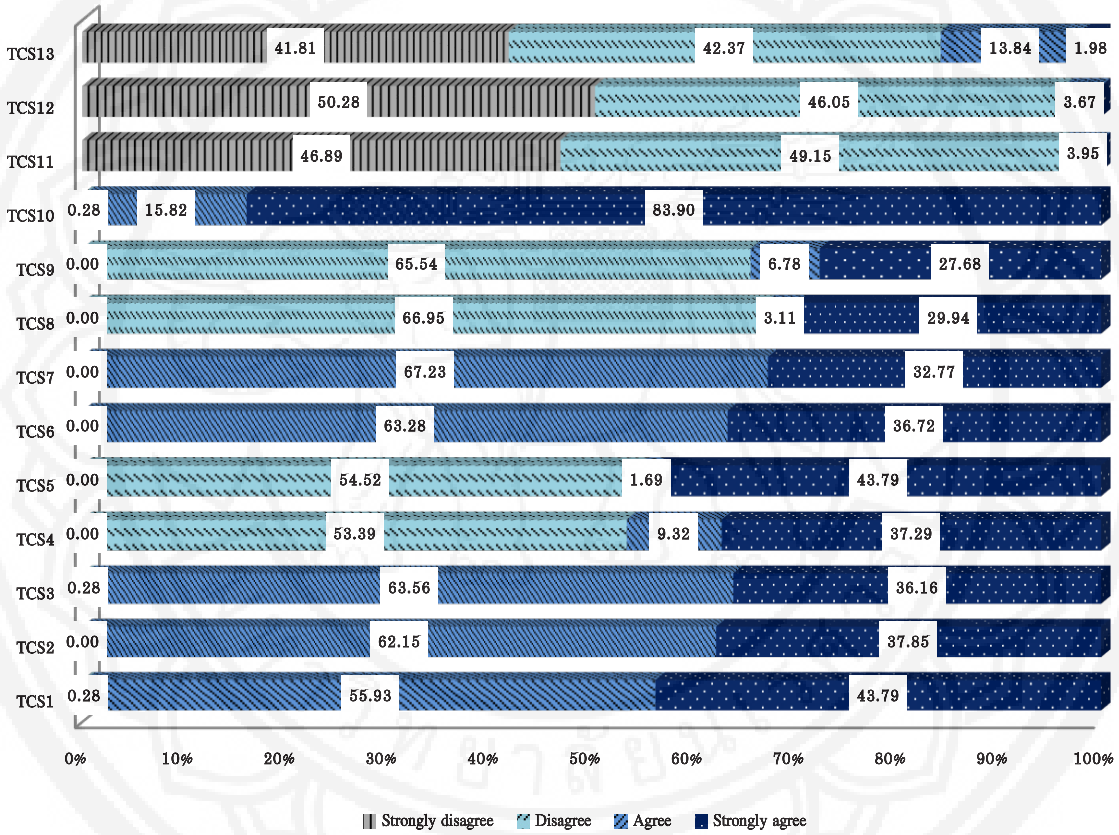

Figure 3 Agreement levels toward implementation of each TCS

Table 6 Rating scores of TCSs (n=414)

Traffic control strategy	Average score	Ranking
Rumble strips or speed humps (TCS1)	3.44	2
Police checkpoint (TCS2)	3.38	3
Incentive program (TCS3)	3.36	5
Community access restriction (TCS4)	2.84	8
Radar speed gun (TCS5)	2.89	7

Table 6 (Cont.)

Traffic control strategy	Average score	Ranking
Traffic lights or signals (TCS6)	3.37	4
Automatic speed camera(TCS7)	3.33	6
Road maintenance (TCS8)	2.63	9
Lane widening (TCS9)	2.62	10
Speed warning or speed limit signs (TCS10)	3.84	1
Legal enforcement (TCS11)	1.57	12
Driving skill improvement (TCS12)	1.53	13
Protection of mental and physical heath (TCS13)	1.76	11

The effects of each TCS were tested using ordered logit. The independent variables used were the 13 TCSs, while the dependent variables used were the 11 causes of negative externalities of STT transportation. To avoid the effect of multicollinearity, the variance inflation factor (VIF) and tolerance (i.e. the statistics used for calculating VIF) tests were performed to investigate any strong association among independent variables. Table 7 indicates that there was some correlation among the 13 independent variables (VIF>1); nevertheless, this weak association (VIF<5) indicated no impact from the multicollinearity problem on the estimation model. The ordered logit model was then developed using SPSS 23, and the results are shown in Table 8.

Table 7 VIF coefficients of independent variables

Variables	Tolerance	VIF
Increase legal enforcement on drivers and operators (TCS1)	0.731	1.367
Improve knowledge and driving skill of truck driver (TCS2)	0.703	1.423
Ensure mental and physical heath of truck driver (TCS3)	0.693	1.443
Increase legal enforcement on safety of truck (TCS4)	0.699	1.431
Increase the number of police checkpoint (TCS5)	0.676	1.48
Set up a period of time to control truck traffic in community (TCS6)	0.742	1.348
Install of traffic light in community (TCS7)	0.679	1.473
Install of speed warning, speed limit signals (TCS8)	0.562	1.78
Increase the width of traffic lane (TCS9)	0.64	1.561
Maintain and repair road surface of traffic lane (TCS10)	0.949	1.053
Increase roundabout and speed humps (TCS11)	0.7	1.429
Install automatic speed camera (TCS12)	0.736	1.36
Use radar gun by police (TCS13)	0.932	1.073

Table 8 Ordered logit coefficients of TCSs

Traffic control strategy	Accidental risk										
	RD1	RD2	RD3	RD4	RD5	RD6	RD7	RV1	RV2	RV3	RV4
TCS1	15.424	14.804	-.431**	-2.648	-15.385	-0.037	-0.131	-1.594	-21.51	-0.075	14.754
TCS2	-0.069	-0.324	0.040	-0.022	-0.132	0.152	-0.125	-0.113	-.514**	-.466**	-0.27
TCS3	15.048	16.092	-2.11	15.908	-15.005	-3.216	-14.565	-.617**	19.468	-0.244	-14.467
TCS4	0.16	0.112	-0.164	-.659**	-0.068	-0.425	-.533**	-0.06	-0.353	0.374	-0.363
TCS5	-0.35	-0.399	0.025	-0.235	-0.157	-0.101	-0.034	-0.352	-0.442	-0.328	-0.422
TCS6	-0.252	-0.066	-0.397	-0.099	-0.259	-0.059	0.474	0.006	-0.244	-0.175	-0.212

Table 8 (Cont.)

Traffic control strategy	Accidental risk										
	RD1	RD2	RD3	RD4	RD5	RD6	RD7	RV1	RV2	RV3	RV4
TCS7	-0.731	-.883**	-0.316	-0.62	-0.323	-0.152	-0.218	-0.412	-0.194	-0.18	-0.195
TCS 8	-0.514	-1.643**	-0.023	-0.084	-0.191	-0.22	-0.255	-0.349	-0.149	0.165	0.214
TCS 9	0.256	0.267	-0.172	.781**	0.21	0.124	-0.212	.631	0.524	-0.048	0.226
TCS 10	14.621	14.443	-1.905	14.224	15.742	15.475	-15.13	19.411	19.569	-2.6	-14.89
TCS 11	-14.682***	-13.698***	3.623	-15.826***	-16.421***	-14.525***	-17.551***	-1.846	-2.861	4.151	-15.781***
TCS 12	-13.132***	-13.209***	-3.271	-13.832***	-16.267***	-15.097***	-15.453***	-3.151	-2.724	-3.93	-16.589***
TCS 13	-14.224	-14.141	0.764	-14.084	-2.373**	-0.082	-0.676	-0.185	-0.1	0.639	-2.242**

Remark *** Indicates significance at 1% level

** Indicates significance at 5% level

Table 8 indicates that most of the TCSs, except the radar speed gun, the traffic lights or signals, and the speed warning or speed limit signs, were statistically significant at either the 1% or 5 % significance level, and mostly indicated negative effects on the negative externalities. Based on this finding, there was sufficient evidence to reject the null hypothesis and accept the alternative hypothesis that the TCSs have impacts on the reduction of causes of STT's negative externalities, but the impacts vary depending on the sign of coefficients.

For engineering TCSs, the installation of rumble strips or speed humps tended to reduce the negative externalities from the STT drivers losing control, while the danger from illegal lane changing was likely to decrease if automatic speed cameras were installed in the communities. These findings were in line with the study of Kanitpong et al. (2013). However, it was somewhat surprising to see that neither the use of radar speed guns nor the installation of traffic lights and signals, including speed warning or speed limit signs, had an effect on addressing the STTs' negative externalities in the five communities. The work of Castillo-Manzano, Castro-Nuño, López-Valpuesta, and Pedregal (2019) could explain the ineffectiveness of the above TCSs. They found that if the number of traffic police was insufficient, the enforcement power decreased and it was difficult to prevent the violations and improve safety. Based on this finding, the lack of legal enforcement could possibly be the cause of the ineffective TCSs in the five communities. Another surprising finding was that widening the road lanes in the communities tended to increase the number of trucks parked unsafely. As there was no parking space provided for trucks in the five communities, most of truck drivers then decided to park their vehicles alongside roads. Hence, widening the traffic lanes would subsequently increase the space for the drivers to park on the roads and the problems from unsafe parking would not be eliminated.

For non-engineering TCSs, the legal enforcement and driving skill improvement indicated large scale impacts on the reduction of the driver-generated externalities, comprising violation of the speed limit, immediate lane changing, unsafe parking, drowsy driving, carelessness of the truck drivers regarding pedestrians at crosswalks, unsafe driving by inexperienced or new truck drivers, and overloading the truck. These findings were in line with the work of Castillo-Manzano et al. (2019) who highlighted the relationship between law enforcement and road safety improvement. Setting up police checkpoints was another possible TCS to address the defect of coupling devices and increase the awareness of the truck drivers to lock the twistlocks before they started a trip. This practice was also recommended in the work of World Health Organization (2016). Another interesting finding of the present study corresponded with the work of Kuiken and Twisk (2001) who found that internal incentive programs aiming at increasing safety standards in the truck companies was an effective TCS to reduce the defects in trucks and driving support devices. Setting up times to restrict freight vehicles accessing the community, introduced by the LCM committees in collaboration with the local traffic police, probably reduced unsafe parking of freight vehicles and the amount of truck driving by inexperienced or new drivers. This finding was in line with the document of Sang-uthai (2017) who described how a community-access-restriction measure reduced the traffic problems in the LCM area. Finally, the road surface maintenance had a likelihood of lowering the impacts of immediate lane changing of truck drivers trying to avoid potholes in the residential road surface and other poor conditions, such as shoulder drop off and the absence of necessary traffic facilities. By maintaining and repairing the condition of roads, the road network would be safer in the longer term (Verma and Singh, 2015), and accident risks would decrease (Malin, Norros, & Innamaa, 2019).

Conclusions

The current study originally identified the potential traffic control strategies (TCSs) and discussed why they were likely to reduce the negative externalities of STT transportation in LCM as a part of EEC area. Compared to the engineering strategies, the non-engineering strategies, especially legal enforcement and the improvement of truck driving and the drivers' knowledge and skills, had a larger impact on the reduction of externalities caused by truck drivers and their vehicles. In contrast, the engineering strategies, such as rumble strips, and speed humps, tended to reduce only the driver-generated externalities. The general roles and responsibilities of the majority of relevant stakeholders have been discussed in the present research; however, analyzing these issues in detail would definitely be useful for increased managerial and theoretical knowledge. The future studies might use the potential TCSs and findings of this study as a reference to generate a conceptual framework regarding STT transportation, sustainability of community, and port sustainability, while the author also plans to continue studying the above topics which will not only contribute to the literature, but also will help policy makers, including governmental authorities, and truck operators, to capture ways they can sustain the communities and their business.

Implications

1. Managerial implications for policy makers and practitioners

The findings of the current study make a considerable contribution to the managerial and policy implications of the truck companies, local policy makers, and governmental authorities involved in the implementation of TCSs in the freight transportation industry and communities. This study highlighted the following managerial implications:

- Traffic police can consider how to increase the enforcement of law in Road Traffic Act A.D.1979 to control violations of the speed limit by truck drivers in EEC areas and other industrial areas not only to reduce road accidents and property damage, but also to increase the effectiveness of other types of TCS. Increasing the number of police officers and the fines are other feasible ways, but the combination of engineering strategies and non-engineering strategies will effectively decrease the bad behavior of the truck drivers.

- The transport and logistics managers are encouraged to provide training courses to improve the driving knowledge and skills required under the legislation on a regular basis to increase the safety awareness of the truck drivers. Training courses emphasizing how to maintain the physical and mental health of truck drivers can help reduce the accident rate. Each trip should be well planned and the vehicles, including the coupling device and twistlocks, should be thoroughly inspected to avoid a truck breakdown which can cause an accident and air pollution. Before being employed, truck drivers need to show they can successfully complete a driving skill and safety course and that they have special license endorsements for operating STTs.

- The Port Authority of Thailand and Laem Chabang municipality are encouraged to provide parking zones with sufficient spaces, free of charge and readily accessible for all trucks to reduce the random roadside parking of trucks in residential areas. The provision of the basic facilities required for ordinary living, such as cafeterias, bathrooms, medical service rooms, and bedrooms, are recommended to maintain the mental and physical health of the truck drivers.

- The enforcement officers of the Department of Labour Protection and Welfare and the Department of Land Transport are encouraged to strictly enforce the relevant regulations to restrict the working hours of truck drivers to reduce drowsiness and fatigue in truck drivers. The DLT is encouraged to strictly control the issuance and validity of licenses to avoid driver license violations because unqualified drivers are a potential cause of accidents.

- It is recommended that the Department of Highways (DH) strictly investigate violations of maximum weight limits to prevent road accidents and property damage by overloaded trucks.

- The truck GPS tracking information should be used to support the implementation of other TCSs or the works of governmental authorities, such as the traffic police, DLT officers, and DLPW officers.

- Collaboration among the Royal Thai Police, Department of Land Transport, Port Authority of Thailand, Laem Chabang municipality, Department of Labour Protection and Welfare, Department of Highways, and truck companies is critical for the success of TCS implementation to prevent the STTs' negative externalities in LCM and other EEC areas.

2. Implications for scholarly knowledge

Promoting sustainability through balanced activities among economic, environmental, and social domains is an obligation for all types of organizations in every industry, including the freight transportation industry. While the economic and environmental issues have drawn most scholarly attention, the current study has provided some original findings which illustrate how the 11 negative externalities from STT freight transportation can be reduced by the implementation of 13 TCSs. The new five non-engineering strategies analyzed highlighted they had a larger scale of impact than the engineering strategies on addressing the dangers of freight transportation. This study can be used as a literature benchmark for future researchers to conceptualize a solid framework with which to analyze the impacts of freight transportation on the sustainability of the community and the country. The findings can be used as a reference for analysis of other managerial concepts, such as collaboration and information sharing, and community involvement in innovative technologies, can sustain the service provision of the transportation sector and other industries.

References

Asgari, N., Hassani, A., Jones, D., & Nguye, H. H. (2015). Sustainability Ranking of the UK Major Ports: Methodology and Case Study. *Transportation Research Part E: Logistics and Transportation Review, 78,* 19-39. https://doi.org/10.1016/j.tre.2015.01.014

Bridger, J., & Luloff, A. (1999). Toward an interactional approach to sustainable community development. *Journal of Rural Studies, 15*, 377-387. https://doi.org/10.1016/S0743-0167(98)00076-X

Brundtland, G. H. (1987). *Report of the World Commission on Environment and Development: Our Common Future.* Retrieved from http://mom.gov.af/Content/files/Bruntland_Report.pdf

BSR. (2011). *Extending Supply Chain Sustainability Metrics to Terminal Operations.* Retrieved from https://www.bsr.org/reports/BSR_Extending_Supply_Chain_Sustainability_Metrics_to_Terminal_Operations1.pdf

Castillo-Manzano, J. I., Castro-Nuño, M., López-Valpuesta, L., & Pedregal, D. J. (2019). From legislation to compliance: The power of traffic law enforcement for the case study of Spain. *Transport Policy, 75*, 1-9. https://doi.org/10.1016/j.tranpol.2018.12.009

Davies, P. (2006). *Off-Dock Storage of Empty Containers in the Lower Mainland of British Columbia: Industry Impacts and Institutional Issues.* Retrieved from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.410.2639&rep=rep1&type=pdf

Denktas-Sakar, G., & Karatas-Cetin, C. (2012). Port Sustainability and Stakeholder Management in Supply Chains: A Framework on Resource Dependence Theory. *The Asian Journal of Shipping and Logistics, 28*(3), 301-320. https://doi.org/10.1016/j.ajsl.2013.01.002

Department of Land Transport. (2015). *Truck Tractor and Trailer and Semitrailer Registration in Thailand.* Thailand: Department of Land Transport.

Duke, J., Guest, M., & Boggess, M. (2010). Age-related safety in professional heavy vehicle drivers: A literature review. *Accident Analysis and Prevention, 42*, 364-371. https://doi.org/10.1016/j.aap.2009.09.026

Eckerberg, K., & Mineur, E. (2003). The use of local sustainability indicators: case studies in two Swedish municipalities. *Local Environ, 8*, 591-614. https://doi.org/10.1080/1354983032000152716

Elvik, R., Christensen, P., & Amundsen, A. (2004). *Speed and road accidents. An evaluation of the Power Model.* Retrieved from https://www.toi.no/getfile.php/131013/Publikasjoner/T%C3%98I%20rapporter/2004/740-2004/Repsumm.pdf

European Agency for Safety and Health at Work. (2010). *A review of accidents and injuries to road transport drivers.* Retrieved from https://osha.europa.eu/en/tools-and-publications/publications/literature_reviews/Road-transport-accidents.pdf

European Environment Agency. (2011). *Do lower speed limits on motorways reduce fuel consumption and pollutant emissions?.* Retrieved from https://www.eea.europa.eu/themes/transport/speed-limits

Hedin, L. T., & Ranängen, H. (2017). Community involvement and development in Swedish mining. *The Extractive Industries and Society, 4*, 630-639. https://doi.org/10.1016/j.exis.2017.04.008

IBI Group. (2006). *Inland Container Terminal Analysis.* Retrieved from http://www.th.gov.bc.ca/PacificGateway/documents/061215_Inland_Container_Terminal_Analysis.pdf

Industrial Estate Authority of Thailand. (2015). *Industrial Estates in Thailand.* Retrieved from https://www.ieat.go.th/en/investment/about-industrial-estates/industrial-estates-in-thailand

Jongmeewasin, S. (2016). *Lesson Learned: Ban Ao Udom Community, Tungsukla, Sriracha, Chonburi.* Chonburi: The Assembly of NGOs.

Kanitpong, K., Jiwattanakulpaisarn, P., & Yaktawong, W. (2013). Speed management strategies and drivers' attitudes in Thailand. *International Association of Traffic and Safety Science, 37*, 39-48. https://doi.org/10.1016/j.iatssr.2012.12.002

Kuiken, M., & Twisk, D. (2001). *Safe driving and the training of calibration. SWOV Institute for Road Safety Research.* Retrieved from https://www.swov.nl/sites/default/files/publicaties/rapport/r-2001-29.pdf

Kumar, A., & Anbanandam, R. (2019). Development of social sustainability index for freight transportation system. *Journal of Cleaner Production, 210*, 77-92. https://doi.org/10.1016/j.jclepro.2018.10.353

Langenus, M., & Dooms, M. (2018). Creating an industry-level business model for sustainability: The case of the European ports industry. *Journal of Cleaner Production, 195*, 949-962. https://doi.org/10.1016/j.jclepro.2018.05.150

Laxe, F. G., Bermúdez, F. M., Palmero, F. M., & Novo-Corti, I. (2016). Sustainability and the Spanish port system. Analysis of the relationship between economic and environmental indicators. *Marine Pollution Bulletin, 113*, 232-239. https://doi.org/10.1016/j.marpolbul.2016.09.022

Leechawengwongs, M., Leechawengwongs, E., Sukying, C., & Udomsubpayakul, U. (2006). Role of Drowsy Driving in Traffic Accidents: A Questionnaire Survey of Thai Commercial Bus/Truck Drivers. *Journal of the Medical Association of Thailand, 89*(11), 1845-1850. http://www.thaiscience.info/journals/Article/JMAT/10401929.pdf

Lu, Y., Geng, Y., Liu, Z., Cote, R., & Yu, X. (2017). Measuring sustainability at the community level: An overview of China's indicator system on National Demonstration Sustainable Communities. *Journal of Cleaner Production, 143*, 326-335. https://doi.org/10.1016/j.jclepro.2016.12.105

Malin, F., Norros, I., & Innamaa, S. (2019). Accident risk of road and weather conditions on different road types. *Accident Analysis & Prevention, 122*, 181-188. https://doi.org/10.1016/j.aap.2018.10.014

Mapar, M., Jafaria, M. J., Mansouri, N., Arjmandi, R., Azizinejad, R., & Ramos, T. B. (2017). Sustainability indicators for municipalities of megacities: Integrating health, safety and environmental performance. *Ecological Indicators, 83*, 271-291. https://doi.org/10.1016/j.ecolind.2017.08.012

Morris, A., Zuo, J., Wang, Y., & Wang, J. (2018). Readiness for sustainable community: A case study of Green Star Communities. *Journal of Cleaner Production, 173*, 308-317. https://doi.org/10.1016/j.jclepro.2017.03.190

Motono, I., Kimito, H., Furuichi, M., & Suzuki, S. (2014). A New Concept of Off-Dock Container Traffic Control for Heavily Congested Ports. In *The Fifth International Conference on Transportation and Logistics (T-LOG).* Bangkok: Chulalongkorn University. DOI: 10.13140/2.1.4295.4887

Quezon, E. T., Wedajo, T., & Mohammed, M. (2017). Analysis of Road Traffic Accident Related of Geometric Design Parameters in Alamata-Mehoni-Hewane Section. *International Journal of Scientific and Engineering Research, 8*(1), 874-881. https://www.researchgate.net/publication/317661305_Analysis_of_Road_Traffic_Accident_Related_of_Geometric_Design_Parameters_in_Alamata-Mehoni-Hewane_Section

Roh, S., Thai, V. V., & Wong, Y. D. (2016). Towards Sustainable ASEAN Port Development: Challenges and Opportunities for Vietnamese Ports. *The Asian Journal of Shipping and Logistics, 32*(2), 107-118. https://doi.org/10.1016/j.ajsl.2016.05.004

Royal Thai Police. (2015). *The Situation of Reported Traffic Accidents by Type of Vehicles, Damages and Alleged Offenders, Central Region: 2013-2015.* Bangkok: National Statistical Office.

Rys, D., Judycki, J., & Jaskula, P. (2017). Impact of Overloaded Vehicles on Road Equivalency Factors and Service Period of Flexible Pavement. In A. Loizos, I. L. Al-Qadi, & T. Scarpas (Eds.), *Bearing Capacity of Roads, Railways and Airfields* (pp. 459-465). Boca Raton, Florida: CRC Press.

Sang-uthai, C. (2017). *The strict control of nine-traffic routes in Laem Chabang Area.* Retrieved from https://mgronline.com/local/detail/9600000070699

Schipper, C., Vreugdenhil, H., & Jong, M. D. (2017). A sustainability assessment of ports and port-city plans: Comparing ambitions with achievements. *Transportation Research Part D, 57*, 84-111. https://doi.org/10.1016/j.trd.2017.08.017

Shi, X., & Li, H. (2016). Developing the port hinterland: Different perspectives and their application to Shenzhen Port, China. *Research in Transportation Business & Management, 19*, 42-50. https://doi.org/10.1016/j.rtbm.2016.05.004

Sislian, L., Jaegler, A., & Cariou, P. (2016). A literature review on port sustainability and ocean's carrier network problem. *Research in Transportation Business & Management, 19*, 19-26. https://doi.org/10.1016/j.rtbm.2016.03.005

Thailand Board of Investment. (2016). *Thailand's Eastern Economic Corridor (EEC): The Special Economic Zone (SEZ) for the Future of ASEAN.* Retrieved from https://www.boi.go.th/upload/content/BOI-book%202016-EEC-EN-TH-20161129_88126.pdf

United Nations. (2015). *Transforming our world: the 2030 Agenda for Sustainable Development.* Retrieved from https://sustainabledevelopment.un.org/post2015/transformingourworld

United Nations. (1982). *A World Charter for Nature.* Retrieved from https://www.un.org/documents/ga/res/37/a37r007.htm

United Nations. (2017). *The Sustainable Development Goals Report 2017.* Retrieved from http://www.undp.org/content/undp/en/home/sustainable-development-goals/goal-11-sustainable-cities-and-communities.html

United Nations Conference on Trade and Development. (2018). *Review of Maritime Transport 2018.* Retrieved from https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf

Verma, D., & Singh, V. (2015). Road Maintenance Effect in Reducing Road Accident. *International Journal for Scientific Research & Development, 3*(1), 303-307. https://www.researchgate.net/publication/315829097_Road_Accidents_and_Prevention

World Health Organization. (2015). *Global Status Report on Road Safety 2015.* Retrieved from https://www.who.int/violence_injury_prevention/road_safety_status/2015/en/

World Health Organization. (2016). *Road Safety Institutional and Legal Assessment - Thailand.* Retrieved from http://www.searo.who.int/thailand/areas/rs-legal-eng11.pdf

Yap, W. Y. (2013). 80 million-twenty-foot-equivalent-unit container port? Sustainability issues in port and coastal development. *Ocean & Coastal Management, 71*, 13-25. https://doi.org/10.1016/j.ocecoaman.2012.10.011