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Maritime autonomous surface ships (MASS): implementation and legal issues

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Abstract

Purpose – The purpose of this paper is to see whether the concept of autonomous ship is having an effect on pioneering the sea transportation as well as improvement of ship safety and the possibility of local development. Following the lead of the first autonomous surface ship by Norway that met to develop the Advanced Autonomous Waterborne Application (AAWA) and introduce of autonomous operation to the region, this study also aims to compare the initiation of action by surface ships to that of the air and land vehicle automation.

Design/methodology/approach – The ideas for writing this paper came from meeting and interview with maritime professionals such as ship captains, marine chief engineers and naval architects. Through the review of various international journals, the development of Autonomy and Technology are explored and analysed. Owing to the practical approach of this paper, a qualitative research method is used with collecting and analysing information.

Findings – The findings of this paper are as follows: it brings out the importance on the potentials of unmanned vessels and its competitive advantages over existing cargo ships. Besides its contribution to reduce fatigue and workload of navigating officers, the improvement of navigational safety by eliminating human errors and reduction of harmful exhaust emission can make shipping safer and more sustainable. However, as the technology is still under development, it is too early for a final evaluation. That said, as the international regulation body, International Maritime Organisation is required to gain acceptance to future unmanned shipping and to designate routes and impose regulations for their safe operation.

Originality/value – Recently, there are many conferences and meetings on autonomous surface vessel focussing on regulation, technology, human-factor, legal and regulatory framework for such ships around the world. This paper summarises the current development of the autonomous surface ships, in term of the design and technology, their interaction and co-existence with manned ships and suggest some operation issues on board an autonomous surface ship during voyage. Taking Hong Kong as an example, this paper attempts to examine the feasibility for introducing the autonomous surface ships in local waters.

Keywords Autonomy, Surface ship, Hong Kong

Paper type Technical paper

1. Introduction

In the past decade, there was a rapid development in the autonomous land vehicle and surface vessels. Autonomous land vehicles are being tested and running in different countries currently; while the world first autonomous surface ship is expected to conduct the testing in 2019 and deliver to commercial operation in Norway by 2020. Then it will
gradually move from manned operation to fully autonomous operation by 2022. Unlike the land vehicles, the autonomous surface ships are more complicated.

Similar to aviation industry, autopilot has a long history in marine industry. In 2016, the Autonomy Level guideline was launched in the UK and provided the route to classification for the autonomous ships. Meanwhile, funded by Finnish Funding Agency for Technology and Innovation, the Advanced Autonomous Waterborne Application (AAWA) had summarised their research on the technological, safety, legal liability and economic aspects of remote and autonomous operation. They proposed the specification and preliminary designs for a proof of concept demonstrator and a remote controlled ship for commercial use by the end of the decade. In 2017, a report by Global Maritime Technology Trends (GMTT2030) in the UK analysed the transformational technologies and offered their perspectives on the future of autonomy, its impact and the timescales. In 2018, there were concerns raised by trade unions of shipping industry around the world. From the result of their survey, they have expressed their view on human factor from the front line operator’s side.

Autonomy vehicle has been used successfully long time ago in a “control” environment, such as a plant or a warehouse, or even within a container terminal recently. In an “open” environment, despite the autopilot has a long history being applied in aviation and marine industry, the level of autonomous in commercial transportation is still in a developing stage. It is observed that the marine industry is lagged behind when compared with the land vehicle.

In 2015, a Maritime Unmanned Navigation through Intelligence in Networks project (European Commission, 2015) has been co-funded by European Commission for an in-depth analysis of the autonomous vessel on safety and security impacts, economic impacts and applicable areas of law. It founded that an autonomous vessel is technically feasible in term of hazard identification and corresponding risk control options. It also found that it would be economic viable in certain circumstances. For the legal aspect, it concluded that the existing legal framework will require some formal amendments but no fundamental substantive obstacles.

A joint human-automation framework (Broek et al., 2017) was studied in 2017 and proposed the migration from human supervision to partial supervision/autonomy stage and finally, the human intervener/fully autonomy stage. To move forward to a fully autonomy sea transportation, shore supports are also required. In 2017, the world’s biggest automated container terminal started her operation in Shanghai. Automated service piers were also studied to a local operation.

2. The concept of autonomy

In the past few years, level of autonomy has been defined for road vehicles and the marine industry (Bureau Veritas, 2017; Lloyd’s Register, 2017). Despite different levels of autonomy, it could be observed that the operation decision is handed over to the system from human at the highest level.

Autonomy starts with a navigation, guidance and control system together with for a dynamic unmanned vessel and algorithm. It includes the guidance system providing navigation and obstacle detection and avoidance (ODA) system. In 2012, a control system adopting Convention on the International Regulations for Preventing Collisions at Sea, 1972 (COLREGs), defined by the International Maritime Organisation (IMO) was studied (Campbell et al., 2012; Naeem et al., 2012). In 2016, the Advanced Autonomous Waterborne Applications (AAWA) [partners developing a set of electronic integrated system for a safety navigation and avoid collisions. The integrated system included three areas: the sensors technology using different types of radars, high definition visual cameras, LiDAR (Light Detection and Ranging), thermal imaging; a control algorithms based on the maritime rules
and regulations for navigation and collision avoidance; and a communication and connectivity for human input from land, to intervene when needed.

3. Implementation of unmanned vessel
Unmanned cars and aircraft have been commonly seen today and few are used in road transportation as well as military engagement. Last year in China, Shenzhen has deployed an unmanned bus in a test trial for in-town transportation, the service received much welcome by the community and proved to be successful. In Europe and the United States, there are also researches into small unmanned underwater and military vessels, some of them are already made available and in use.

In maritime industrial sector, there had been also researches into the unmanned surface and underwater vehicles. Initially these researches used the idea of remoted control functions on relative small crafts but as the demand grew larger, the size of these crafts are increasing. Developing a large unmanned cargo vessel involves similar idea but the implication would be far greater than land and aviation. Since over 80 per cent of worldwide cargo transportation is carried out by sea, it is considered to be one of the main driving forces of today’s global economy. It would be a great step forward that a reliable and sustainable transportation system of unmanned vessels can be introduced in the sea transport.

In Norway, a ship similar to the actual size of a cargo vessel is being built as an unmanned cargo carrying vessel. “Yara Birkeland”, is an autonomous container ship under construction and due to be launched in 2019. The “Yara Birkeland” project is planned to be the first fully autonomous logistics concept from industrial site operations, port operations and vessel operations in the world.

Comparing with the current cargo ships, the reliability and capability of the Artificial Intelligence Components (AIC) in terms of safety, ecological and cost effectiveness would be a main concern for the merit to develop unmanned shipping. Scepticism regarding unmanned vessels would exist and thus one must perceive those unmanned vessels are at least as safe as or even safer than the current cargo ships. It is also expected that the future unmanned vessel should be able to resolve some of the problematic issues that are facing with the current shipping.

Operationally, an unmanned vessel will chiefly be guided by AIC with automated navigational system on-board which make decision based on the detected surrounding situations. In case of an un-predetermined situation occurring to the unmanned vessel, it will automatically alert the Shore Command Centre (SCC). The SCC is a backup facility in which the unmanned vessel would be operated at ashore. Using communication satellites as bridges the unmanned ship and SCC will be constantly linked up.

The possibility to navigate below the sea surface during the ocean passage will also be explored in the latter part of this paper. Using battery as its means of propulsion the unmanned vessel might sail beneath the sea surface in the designated ocean route at a pre-assigned depth. Because of being submerged, the resistance between the surface water and the hull would be greatly reduced and the speed improved. Besides, the submerged vessel would be able to avoid adverse weather condition and dense surface traffic.

3.1 Safety of navigation
Today, the responsibility of ship officer is ever increasing because of various navigational duties and paper work throughout the voyage. During coastal voyages, schedules would be even tighter. Frequent port call and prolong hours of navigation in busy coastal water would render stress to the navigating officers. As the number of navigating officers on board is barely sufficient, these stresses could build up as a result of heavy workload causing fatigue and exhaustion.
Furthermore, the navigating officer is often left to remain the sole responsibility on the bridge while requiring to render to situations that might not be properly perceived and responded to. Although the STCW Convention has imposed stringent competency requirements to the navigating officers, things may go wrong when under constant stress condition. On the other hand, ocean crossing passage is quite the contrary. At sea, workload on navigation is less threatening as there is only little traffic during an ocean passage. Although this could allow opportunity for the navigating officer to relax but there are possibilities that it could also result in low situation awareness. As a result occasionally accidents such as ship collisions and groundings do occur. Investigation to these accidents reveals that over 80 per cent are caused by human error. Common human factors such as fatigue, error of judgment and low situation awareness often contribute to the cause of marine accidents. One of the motives behind the research of unmanned vessel is to enhance the safety of navigation and resolve the problem of human errors in maritime accidents. With the introduction of unmanned vessel and autonomous collision avoidance navigational system and because the vessel is to operate without human intervention, it is envisage that the problem of human error should be alleviated.

3.2 Shortage of seafarer
The supply of ship officers to the shipping industry will not be sufficient in future years. A study by Drewry Shipping Consultants has sounded the alarm that owing to the number of new buildings coming on line and youngsters’ reluctance to go to sea, the shortage of ship officers will be worsened in the years to come. The study found that the current moderate shortage for ship officers in the world merchant fleet will not be resolved unless training is increased or measures are taken to address the situation and that the current worldwide supply in the next five to ten years will probably not satisfy future demand for officers.

3.3 Harmful exhaust emission
One of the fundamental motivations to the development of an unmanned vessel is to contribute a more sustainable maritime transport industry by reducing fuel consumption cost and harmful exhaust gas emission. At present, fierce competition between shipping companies has put a lot of economic pressure on all parties involved in maritime transportation. Cost of bunker fuel being one of the major causes. At the same time, the IMO imposes stringent requirements to ships for reducing of harmful exhaust emission. Whilst the global requirement of 0.50 per cent sulphur cap on exhaust emission will enter into force in 2020, more than 70,000 ships will be affected by the new requirement. This necessity to reduce costs and harmful emissions would cause shipping companies to consider the alternatives of propulsion means such as battery through slow steaming.

3.4 Operation of unmanned vessel
During the initial stage, most of the main control functions such as pre-planning of voyage and choice of routes will still be performed by the SCC. However, on scene navigation control functions such as pre planned actions for collision avoidance and course setting will be taken over by the Sensor System on board. The Sensor System is supported by the radar, high definition visual cameras, LiDAR, thermal imaging and AIC etc.

In principle, the detection functions are based on existing and reliable navigational sensors with the radar still being the main source of information. From a navigational safety perspective, the system must ensure that a single technical failure is not compromise the
whole unmanned ship’s capability to meet the safety-critical functions so that the vessel will be constantly operated under all safety parameters.

For routine operation of unmanned shipping, three implementation stages on departure, ocean passage and arrival would be identified. A team of navigation crew will board the unmanned vessel after it completes the ocean passage and approaches to the coastal water of the destination port. The crew will then navigate the vessel in a conventional manner until it arrives the berth. Loading or discharge of cargo will be carried out after berthing. Upon departure, the crew will navigate the vessel away from the busy coastal water to a position where the ocean passage commences. The crew set the vessel to unmanned execution mode for ocean sea navigation under full auto mode and disembark. After that, the ship will sail by itself in unmanned mode until it reaches the coastal water of the destination port.

During the full autonomous mode while at ocean sea passage, status of vessel will be constantly transmitted to shore via satellite communication to enable safe monitoring. The vessel will now proceed on its pre-planned track according to the voyage plan and the environmental data is obtained and monitored by its auto detection sensors such as radar and collision avoidance systems.

The setting and design of the AIC and Sensor System should be based in accordance with the appropriate international legal requirements, such as the International Prevention of Ship Collision Regulations. If a close quarter situation with another vessel is encountered, the Sensor System will recognise the traffic situation and the AIC will respond to it according to Collisions Regulations. Should floating objects or fishing nets be discovered, the vessel will carry out a respective evasive manoeuvre as well.

As soon as a situation is encountered which the Sensor System is not capable of dealing with, human assistance can be sought from the SCC through the AIC. The vessel will be switched automatically into remote control mode and communicate to a shore-side human operator in the SCC via communicate satellites. If required, the human operator will deal with the situation and give direct actions and command to the vessel via the SCC. It is envisaged that the intervention through SCC should gradually reduce, as the auto mode Sensor System are further developed to meet different type of situations.

The concept of the SCC envisages a backup facility in which the unmanned vessel would be operated. Other than autonomous function of the unmanned shipping, the operator might supervise a number of ships of similar types in the SCC. The SCC is to be set up like a full-scale ship’s bridge ashore and be executed by a trained operator who may be an experienced master or watch-keeping officer. The role of the SCC is to back-up the safety function of the automatic system on board is to ensure un-predetermine situations are properly dealt with. During the voyage, the navigational processes and relevant actions taken must be recorded and mapped to facilitate future improvement of the system.

3.5 Vulnerability to hijacking control
In the maritime sector, remote control and autonomous navigational system on board the unmanned vessel brings benefits for safety and efficiency such as artificial intelligence components and sensor system, however, as unmanned ships are interconnected through land and satellite networking, it is possible that they would be exposed to cyber threats.

In 2016, after consultation with the members on what maritime cyber security guidelines should look like, the IMO issued the interim cyber security risk management guidelines. These guidelines enable services that are critical for safety and rescue operations, navigation and communication in a physically remote environment to be protected from cyber threats.

Although cyber security attacks on maritime infrastructure have not yet gained critical momentum, a cyber-attack response and prevention plan by first identifying vulnerabilities
are to be maintained. The informational technology and security experts should run regular incident tests to identify weaknesses and strengthen the on board security programme to avoid possible attack from hackers.

3.6 Support of the International Maritime Organisation
In recent years, the IMO has developed guidelines for assessing the risks relating to maritime safety of the autonomous vessels. As the introduction of a concept for unmanned vessels will surely benefit the future development of technology, a thorough review is necessary to identify those hazards which are affected by the operation when these unmanned vessels actually comes into the picture.

Another proposals of IMO’s e-Navigation concept is for Automatic Identification System to extend its function to ships in which it would additionally display their intended routes to the SCC or other reception facilities. This service will no doubt be another great benefit to vessel interaction in the development of the AIC of unmanned shipping.

As for the time being, the IMO may consider the introduction of the following measures:

Similar to Traffic Separation Scheme that had been designated in congested traffic water areas, the IMO should consider to designate ocean routes for unmanned vessel. Requirement should be established for member states to register main ocean routes in the Exclusive Economic Zones and High Sea. The designated ocean routes are to be used exclusively for unmanned vessels transiting the sea area under the revised Collision Regulations. Furthermore, for safe operation of the unmanned vessels, special rules and regulations are to be introduced in both surface and submerged conditions.

It is envisaged that future hull structure of unmanned vessels would be designed to fit for both surface and under water navigation. Using battery as its means of propulsion, it is believed that the unmanned vessel should be free from any emission and reduce air pollution to the environment.

3.7 Pros and cons
To summarise, the following are the pros and cons for developing unmanned shipping:

(1) Pros:
   - elimination of harmful emissions;
   - decrease of human error risk and the resulting associated accidents;
   - reduction of fuel costs;
   - offsetting the expected shortage of seafarers in the future;
   - reduction of total operating expenses; and
   - increase the reliability and efficiency in future sea transport.

(2) Cons:
   - technology still under development;
   - possible reduction of seafarer jobs;
   - unknown safety risks due to uncertain technology reliance; and
   - vulnerability to computer hackers hijacking control.

4. Legal aspects concerning unmanned ships in Hong Kong
There are major international IMO treaties and Hong Kong legislation that are applicable to the Shipping operations in Hong Kong. To limit the scope of our study, we only confine ourselves with the study of cargo ships engaged on international voyages. If these “unmanned” ships can comply with the local laws and regulation, they can operate in Hong
Kong or if not, the international laws and domestic legislation are needed to be amended
with clarifications to cater for “unmanned” cargo ships before these ships can be operated in
international waters or in the waters of Hong Kong.

4.1 Master’s role on board ship
The master of a ship has the sole command of the ship but also has all the responsibility
concerning all matters that happens to the ship or that requires by the laws and regulations.
The maritime legislation considers the master of a ship is a person in charge of the ship, who
has ultimate authority and responsibility to make decisions with respect to ship’s health,
security, safety and environmental protection matters.

Chapter 1 of the Laws of Hong Kong – Interpretation and General Clauses Ordinance of
provides the following: “master”, when used with reference to a vessel, means the person
(except a pilot) having for the time being command or charge of the vessel.

Under the International Convention for the Safety of Life at Sea (SOLAS), the master of
the ship is required to perform a number of duties related to the ship. The SOLAS and the
International Convention for the Prevention of Pollution from Ships, 1973 as modified by the
Protocol of 1978 (MARPOL 73/78) conventions are enforced in Hong Kong through Cap.369
and Cap.413 Ordinance, etc. and their subsidiary legislations. These duties and
responsibilities are required under SOLAS and the Hong Kong legislation.

The master of the ship is vested with duties, powers, responsibilities or discretions
which he is obliged to discharge or exercise for the safe operation of the ship under
international treaties and domestic legislation. Do the existing international maritime
regulations require that the master or officers or crew necessarily be on board the ship
during a voyage or on a sea passage? Some people say without the master or officers or
crew on board may render the ship unseaworthy. The unmanned ship may not be able
to comply with the Collision Regulations (COLREGs) as the action required for collision
avoidance shall, if the circumstances of the case admit, be positive, made in ample time
and with due regard to the observance of good seamanship. When the traditional role of
the master of the ship will not be there and the master’s responsibilities and liabilities
will be transferred to other shore-based operators. Compulsory pilotage is another issue
that may have an impact on the operation of unmanned ships as compulsory pilotage
requirements or regulations vary from port to port.

The IMO has now taken a more proactive and leading role on MASS due to the rapid
technological developments in recent years. The Maritime Safety Committee (MSC) and the
Legal Committee (LEG) have now agreed on regulatory scoping exercises and gap analysis
to see if, where and how unmanned ships will fit in existing maritime conventions and
regulations. Furthermore, the impact on the controls of United Nations Sanctions and
embargoes on unmanned ships should also be studied by the United Nations and the IMO
for the prevention of using the unmanned ships for illegal sea transportation.

5. Conclusions
This paper has demonstrated the potentials of unmanned vessels and its competitive
advantages over existing cargo ships. Besides its contribution to reduce fatigue and workload
of navigating officers, the improvement of navigational safety by eliminating human errors
and reduction of harmful exhaust emission can make shipping safer and more sustainable.
However, as the technology is still under development, it is too early for a final evaluation. That
said, as the international regulation body, IMO is required to gain acceptance to future
unmanned shipping and to designate routes and impose regulations for their safe operation.
<table>
<thead>
<tr>
<th>Ship category</th>
<th>Level of autonomy</th>
<th>Manned</th>
<th>Method of control</th>
<th>Authority to make decisions</th>
<th>Actions initiated by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>0</td>
<td>Human operated</td>
<td>Yes</td>
<td>Automated or manual operations are under human control</td>
<td>Human</td>
</tr>
<tr>
<td>Smart</td>
<td>1</td>
<td>Human directed</td>
<td>Yes/No</td>
<td>Decision support</td>
<td>Human makes decisions and actions</td>
</tr>
<tr>
<td>Autonomous</td>
<td>2</td>
<td>Human delegated</td>
<td>Yes/No</td>
<td>Human must confirm decisions</td>
<td>Human</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Human supervised</td>
<td>Yes/No</td>
<td>System is not expecting confirmation</td>
<td>Human is always informed of the decisions and actions</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Fully autonomous</td>
<td>No</td>
<td>System is not expecting confirmation</td>
<td>Human is informed only in case of emergency</td>
</tr>
</tbody>
</table>

**Note:** Definitions of the level of autonomy are given in Sec 2, Tab 16
As for Hong Kong, the maritime traffic density in the waters of Hong Kong is high and the traffic patterns in Hong Kong are also complex. The present legal frameworks are also hurdles for unmanned ship implementation. We do not anticipate that unmanned ships could operate within the port of Hong Kong even after IMO has resolved the legal issues. However, with the rapid development of the artificial intelligence system and other control technologies, IMO should re-visit the “Principles of Safe Manning” as adopted by IMO resolution A.890(21) as amended by resolution A.955(23) to take into account the operation of Shore Command Centre and Shore-based Operators and to allow further reduction of the number of crew on board. Only when these international legal framework becomes operational and feasible to the maritime industry, Hong Kong could attempt to consider the autonomous ship application in our waters (Tables I and II).

References

Table II.
LR Code for unmanned marine systems – autonomy levels

<table>
<thead>
<tr>
<th>Autonomy Levels (AL)</th>
<th>Manual to Fully autonomous</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL 0) Manual</td>
<td>Manual</td>
<td>No autonomous function. All action and decision-making performed manually. Human controls all actions.</td>
</tr>
<tr>
<td>AL 1) Decision Support</td>
<td>On-board Decision Support</td>
<td>All actions taken by human operator, but decision support tool can present options or otherwise influence the actions chosen. Data are provided by systems on board.</td>
</tr>
<tr>
<td>AL 2) Decision Support</td>
<td>On and Off-board Decision Support</td>
<td>All actions taken by human operator, but decision support tool can present options or otherwise influence the actions chosen. Data may be provided by systems on or off-board.</td>
</tr>
<tr>
<td>AL 3) ‘Active’ Human in the loop</td>
<td>‘Active’ Human in the loop</td>
<td>Decisions and actions are performed with human supervision. Data may be provided by systems on or off-board.</td>
</tr>
<tr>
<td>AL 4) Human on the look</td>
<td>Human on the look</td>
<td>Decisions and actions are performed autonomously with human supervision. High impact decisions are implemented in a way to give human operators the opportunity to intercede and override.</td>
</tr>
<tr>
<td>AL 5) Fully autonomous</td>
<td>AL 5) Fully autonomous</td>
<td>Rarely supervised operation where decisions are entirely made and actioned by the system.</td>
</tr>
<tr>
<td>AL 6) Fully autonomous</td>
<td>AL 6) Fully autonomous</td>
<td>Unsupervised operation where decisions are entirely made and actioned by the system during the mission.</td>
</tr>
</tbody>
</table>
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Examining performance change and its drivers in Irish ports 2000-2016

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Abstract

Purpose – The purpose of this paper is to examine performance change in the Irish state-owned port sector over the 2000-2016 period using a case study approach.

Design/methodology/approach – For analysis, qualitative sources are used to construct an explanatory account for the quantitative measures of productivity, profitability and traffic shift-share change across the major ports within the system.

Findings – The results show that overall change in performance largely follows that of the macro-economic performance of the region, characterised by pre-recession growth, decline during the recession and post-recession recovery. Across the ports, however, there was a notable divergence in performance post-recession. Identified factors affecting performance change across the period include demand-side structural change, labour rationalisation and degree of private sector participation.

Originality/value – This study addresses a gap in the formal evaluation of port performance in Ireland. The study further demonstrates the potential of in-depth case study analysis for uncovering insights into the drivers of performance across a number of dimensions, thus allowing for the contextualisation of results. The study of a small number of cases enables the use of rich qualitative sources to create strong narratives, which combined with quantitative measures of performance, can lead to new insights.

Keywords Mixed methods, Total factor productivity, Case study, Seaports

Paper type Research paper

1. Introduction

Accounting for 85 per cent of the total volume and 56 per cent of the total value of merchandise trade, the shipping sector is a critical enabler of Ireland’s trading capacity (Vega and Hynes, 2017). Despite its importance, the volume of demand for port services is limited by the relatively small size of the Irish hinterland and peripherality of the region towards major trade lanes (making Irish ports unsuitable for trans-shipment traffic). Without a sizeable volume of demand, there are concerns as to the viability of a market mechanism for ensuring competition and subsequent competitiveness within the sector.
Thus, the effective performance of the Irish seaport sector is a strategic objective at the national policy level with the sector seeing a number of reforms and policy initiatives since the initial reform with the passing of the Harbours Act 1996-2000 (Department of Transport Tourism and Sport, 2013). However, despite its recognized importance, there has been little formal evaluation of performance within the port sector in Ireland. Mangan and Cunningham (2000) performed an early performance evaluation of the effects of the full enactment of the Harbours Act in 2000. The authors found that the programme of reform was largely successful in commercializing the ports. However, they argued that it would take more time and further reviews to fully assess the impact of reform. In 2002, a review into the success of the governance reform was officially commissioned and undertaken by Raymond Burke Consulting (Burke, 2003). The resulting report was largely supportive of the trajectory of reform and supported the view that there were improvements from commercialization. The report did, however, highlight a few outstanding issues as causes for concern, most prominently, ambiguity surrounding the future exchequer funding of port infrastructure development. Subsequent to these initial reviews of post-reform performance, there has been little further evaluation of the performance of Irish ports.

This paper seeks to address this gap through an examination of performance change within Irish ports for the 2000-2016 period. A key challenge in examining performance change over an extended period of time is accounting for the environmental factors external to the control of the individual port managers who drive performance. Ports and port systems evolve over time and in response to various forces in the port and maritime industry (meso), and wider macro-economic environment in which the ports are embedded (Beresford et al., 2004; Sánchez and Wilmsmeier, 2010; Wilmsmeier and Monios, 2016). Demand for port services is derived from the requirements of international trade, and ports evolve relative to changes in the nature of this demand. The capability of ports to sustain performance because of changes in the ports contextual environment represent a key aspect of port performance, which was recently identified by Notteboom (2016) as the ports’ adaptive capacity. In the Irish situation, the time period under review includes a period of unprecedented boom and bust and subsequent recovery.

To measure performance using conventional comparative methods, there is a need to account for this complexity. Without doing so, creates a risk of confounding cause and effect in inference between managerial effectiveness (or Leibstein’s X inefficiency) and naturally occurring heterogeneity occurring in the port authorities’ (PA) contextual environment (Bergantino et al., 2013; Pilcher and Tseng, 2017). Respective of this challenge, a mixed methods case study approach is adopted to analyse performance change over time. Here productivity, profitability and traffic shift-share growth are measured for selected ports within the state-owned port system. Qualitative sources are then referenced to contextualise the change in observed productivity in terms of external environmental and internal managerial factors that influenced the change in observed performance. Thus, the approach allows for the contextualisation of performance in respect of the key drivers that have influenced observed performance change. Given the case study’s longitudinal nature, this affords the opportunity to examine how port managers have adapted to major economic environmental change over time. Therefore, the objective of the paper is to examine performance change across Irish ports and identify the internal and external drivers that have influenced performance change over time.

The remainder of the paper is structured as follows. Section II introduces the case description, detailing the policy framework. Section III outlines the methodology used and data sources used to complete the analysis of performance. Section IV presents the case
study results and includes a discussion and synthesis. Section V examines the implications of the result for Irish policy makers as well as the conclusion.

2. Case description
The state-owned port sector in the Republic of Ireland was created in its current guise under the Harbours Acts 1996-2000. Prior to 1996, Irish port infrastructure was controlled by harbour authorities, which had a high degree of direct government departmental control (Mangan and Furlong, 1998). There was a growing concern regarding the suitability of these governing arrangements for the effective development of port infrastructure. Mangan and Furlong (1998) reported the inadequacy of board of directors composition and highlighted the degree of ministerial approval required for operational change, including the setting of rates, borrowing money, carrying out harbour improvements and acquiring and disposing property. Such concerns and a growing culture of public administration reform (owing to the advancements of new public management in the late 1980s) led to the appointment of a review group in 1991. The findings of the review recommended reform by concluding that Ireland’s ports have been severely constrained in their ability to commercially respond because of the restrictive legislation under which they operate (Mangan and Furlong, 1998).

Based on the recommendations of the review group, the Harbours Act 1996-2000 was enacted[1]. The act commercialised the 10 largest state-owned ports and created commercial state-owned enterprises. The government retained ownership as the sole shareholder with the resulting “port companies” given a largely commercial mandate. Most operating restrictions were removed; however, the port companies still required ministerial approval regarding large-scale borrowing and the establishment of subsidiary companies. New boards of directors were established to be responsible to the minister for the conduct and operation of the port companies. As described in the Ports Policy Statement 2005, the legislation was intended to give key Irish ports the commercial freedom to operate as modern customer-oriented service industries, and in the process providing more cost-effective and efficient services to meet the needs of their customers. In commercialising the ports rather than fully privatising them, the recommendations of the review group were followed. The group found that privatisation was not at the time a realistic option given the complexity of the process and uncertain additional benefits.

The sector was further reformed in 2013 with the introduction of National Ports Policy (2013) (NPP), which outlined a strategy to tier state-owned ports based on a combination of their throughput, market share and capability to provide capacity for future growth to serve the national interest. Tier 1 and 2 ports were classified as ports of national significance and are to be retained under full state ownership, while Tier 3 ports of regional significance are to be transferred to local authorities. NPP states that Tier 1 ports are mandated to ‘lead the response of the State commercial ports sector to future national port capacity requirements’ with Tier 2 ports also recognised as having a responsibility to develop additional national capacity. In this way, NPP is a move away from the previous policy of multiple independent competing ports. NPP cites the wider trend towards consolidation in the shipping market and the use of larger ships as influencing factors.

While, in total, ten ports were subject to initial reform under the Harbours Act 1996, it is not possible to look at all ten ports in sufficient detail. For this reason, the largest four state-owned ports were selected for examination: Dublin Port, Port of Cork, Shannon Foynes Port Company and the Port of Waterford. After NPP, these are the ports that remain under state governance in addition to Rosslare[2]. Figure 1 shows the location of each of the ports sampled as well as the other large ports on the island, while Table I lists the key characteristics and competitive position of each of the ports in 2000.
3. Methodology
A case study approach involves an in-depth analysis of a limited number of cases that involve generally more variables than large sample studies (George and Bennett, 2005; Yin, 2013).

3.1 Analytical approach
The analysis comprises a quantitative summary of the evolution of performance among the sub-units from 2000 to 2016. In completing the quantitative summary, a mixed methods approach is used as described by Gertler et al. (2016) as follows:

Qualitative data provide context and explanations for the quantitative results, to explore outlier cases of success and failure, and to develop systematic explanations of the program’s performance as it was found in the quantitative results.

The approach comprises first measuring performance using quantitative methods and second using qualitative sources to construct an explanatory account for quantitative measures of productivity change across the major ports within the system.

The conventional approach in the literature toward the effect of contextual factors on port performance is to use quantitative methods, which are mostly regression approaches. Examples of recent studies include Bergantino et al. (2013) who examined the effect of regional GDP, employment, population density and access on port efficiency, and De Oliveira and Cariou (2015) who looked at the effect of market competition on efficiency in container terminals. A restriction of this approach is that it, by design, limits the scope for discovery of new explanatory sources of heterogeneity to variables identified in advance. This is not always desirable because, given the complexity of port infrastructure systems, what influences behaviour is not necessarily apparent to the researcher. The advantage of the approach is that by not restricting the analysis to a chosen set of ex-ante variables.
(which is by design necessary for a large sample study), we increase the probability that new variables and critical relationships among them are discovered (Eckstein, 2000).

### 3.2 Measuring total factor productivity and profitability

The main metric used is a measure of total factor productivity (TFP). Productivity relates to the process by which a production unit converts inputs into outputs. TFP measurement is distinct from partial productivity measurement as it relates all inputs in the production process to outputs. Changes in TFP, therefore, provide a good approximation to how effectively the port enterprise is managing its resources. Increases in productivity occur when the ratio of output produced to input consumed increases (Coelli et al., 2005).

There is an extensive literature that has examined productivity change in the port sector. Studies can primarily differentiate between those that examine TFP at the terminal level (Wilmsmeier et al., 2013; Song and Cui, 2014) and those that examine productivity at the port and port authority level (Barros and Peypoch, 2007; Barros et al., 2012). With the exception

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<table>
<thead>
<tr>
<th>Port Name</th>
<th>Key Characteristics and Market Position</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dublin Port Company</strong></td>
<td>Dublin port is the largest port on the island of Ireland, handling all five major traffic types. In the year 2000, the port held market leading positions in both the RoRo and LoLo markets. To service these markets the port benefits from close proximity to the largest population base in Ireland, the Dublin metropolitan area, and the UK, Ireland's largest trading partner. The port facility is located in the city and consists of dedicated terminals and common user facilities.</td>
</tr>
<tr>
<td><strong>Traffic in year 2000 000's tonnes (Market Share)</strong></td>
<td>RoRo</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------</td>
</tr>
<tr>
<td>6536 (35%)</td>
<td>4176 (55%)</td>
</tr>
</tbody>
</table>

<p>| <strong>Port of Cork</strong>           | The port of Cork is the third largest port on the Island of Ireland and second largest port in the Republic of Ireland. It handles all five major traffic types and in the year 2000 was seen to specialise in liquid bulk traffic. The port is located on the south coast and has a number of separate facilities located around Cork harbour. |</p>
<table>
<thead>
<tr>
<th><strong>Traffic in year 2000 000's tonnes (Market Share)</strong></th>
<th>RoRo</th>
<th>LoLo</th>
<th>Liquid Bulk</th>
<th>Dry Bulk</th>
<th>BreakBulk</th>
</tr>
</thead>
<tbody>
<tr>
<td>191 (1%)</td>
<td>968 (13%)</td>
<td>6365 (46%)</td>
<td>1556 (11%)</td>
<td>139 (10%)</td>
<td></td>
</tr>
</tbody>
</table>

<p>| <strong>Shannon Foynes Port Company</strong> | Shannon Foynes Port Company specialises in the handling of Bulk traffic, and is the largest Bulk port on the Island of Ireland. In the year 2000 the port consisted of a number of user dedicated terminals and two common user terminals, spread out across the deep water Shannon Estuary on the west coast. |</p>
<table>
<thead>
<tr>
<th><strong>Traffic in year 2000 000's tonnes (Market Share)</strong></th>
<th>RoRo</th>
<th>LoLo</th>
<th>Liquid Bulk</th>
<th>Dry Bulk</th>
<th>BreakBulk</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>1903 (14%)</td>
<td>8230 (57%)</td>
<td>150 (9%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<p>| <strong>Port of Waterford</strong>      | The Port of Waterford is located on the South East of the island and handles four of the five major traffic types. In the year 2000 the port company was overseeing the movement of facilities from the ports traditional location in the city quays to a new location further along the coast. |</p>
<table>
<thead>
<tr>
<th><strong>Traffic in year 2000 000's tonnes (Market Share)</strong></th>
<th>RoRo</th>
<th>LoLo</th>
<th>Liquid Bulk</th>
<th>Dry Bulk</th>
<th>BreakBulk</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td>1014 (13%)</td>
<td>245 (2%)</td>
<td>498 (3%)</td>
<td>115 (7%)</td>
<td></td>
</tr>
</tbody>
</table>

Source: Own authors composition based on Eurostat data
of a number of early studies such as Kim and Sachish (1986), TFP in port studies has been measured using frontier methods. This approach involves using either parametric (stochastic frontier) or non-parametric (data envelopment analysis, free disposal) estimation methods to estimate production possibility frontiers or using TFP indices to measure the change in productivity over time. The major advantage of a frontier approach is by estimating a production possibility frontier, which allows for the decomposition of productivity change into its constituent parts, i.e., TFP changes because of shifts in the production possibility frontier (technical change), because of increases in technical efficiency and by changes owing to increases in scale.

There are, however, significant challenges in the current case for estimating the production frontier. A sample of homogeneous production units is required to reliably estimate a production possibility frontier. In the Irish case, the number of firms in the set is quite small and there is a high degree of heterogeneity between relatively small break bulk and large multimodal ports. This limits our capability to properly estimate the production frontier. For this reason, an index price approach is adopted to measure TFP change in Irish ports over time.

The index price approach uses input and output prices to weight the contribution of respective outputs and inputs to TFP, and it has been used to examine performance change in productive units when data limitations are in place (See and Coelli (2013) and Palcic and Reeves (2015)). In the current study, following See and Coelli (2013), a Tornqvist index is calculated using price information. This involves a simple calculation of an output index over the input index. Both input and output indexes are generated using cost/price shares to weight the contribution of inputs of outputs. Productivity change is then calculated relative to a base year as follows:

$$\text{Tornqvist TFP Index} = \frac{\text{Tornqvist Output Index}}{\text{Tornqvist Input Index}}$$

$$= \frac{\prod_{j=1}^{m} \left( \frac{y_j}{y_j^s} \right)^{\frac{\tau_j^t - \tau_j^s}{\tau_j^t}}}{\prod_{n=1}^{N} \left( \frac{x_n}{x_n^s} \right)^{\omega_n^t - \omega_n^s}}$$

where \( y \) represents output \( j \) at time \( t \), while \( \tau \) represents the output price. Similarly, \( x \) represents input \( j \) at time \( t \), while \( \omega \) represents input cost. In this manner, taking year \( s \) a reference year productivity change is simply interpreted as a result of a change in input consumption relative to output production. The change in respective output is easily related to the qualitative data describing the consumption of inputs in a given year and major factors that have influenced output generation.

The drawback of using an index number approach is it is not possible to decompose the source of productivity change as described above. Secondly, any interpretation of productivity is relative to the firm in the base year chosen, and, as such, comparisons between the productivity of two firms are not possible. All that is possible is a comparison of rates of productivity changes over time.

To select inputs for the index, an approximation of labour and capital were chosen as the two inputs. Labour was measured as the number of full-time employees of the respective port companies. Cost share was calculated as the staff cost in a given year as reported in the financial accounts[3]. Capital is typically more complex to measure. As information on
capital assets is available from vesting day for each port company, the perpetual inventory
method was chosen following the method outlined in See and Coelli (2013), which was used
in the Irish context by Cahill et al. (2017). Measuring capital in this way allows for control for
the use of different depreciation methods across companies, which can affect the true value
of tangible assets, represented in the company’s accounts. The quantity of capital is
measured as follows:

\[ K_t = K_{t-1} + I_t - \theta_t - R_t \]  

(3)

where \( K_t \) is the real depreciated capital stock in period \( t \) and \( t-1 \). \( I_t \) is the real investment in
period \( t \), \( \theta_t \) is a real value of disposals in period \( t \) and \( R_t \) represents real retirements[4]. Cost
of capital was calculated following Cahill et al. (2017) as follows:

\[ CK_{kt} = \sum_{k=1}^{N} (i_t + \delta_{kt})NomFA_{kt} \]  

(4)

where:
- \( k \) = each asset group;
- \( i \) = ten year bond yield on government securities;
- \( \delta \) = depreciation rate; and
- \( NomFA \) = Nominal value of each group of fixed assets.

In terms of outputs, while it is desirable to use all possible outputs of the firm, a lack of price
data means we were restricted to using revenue as a single output[5]. In addition to TFP, the
operating margin was measured to account for profitability. While there should be a positive
relation between profitability and productivity, an increase in productivity means that a
firm is now producing output with proportionately less input. In practice, it is not always the
case because factors often related to external to operations can affect profitability (Bai et al.,
1997). Therefore, the operating margin (ratio of operating profit to revenue) is measured to
examine whether increases in productivity are translated to profit.

3.3 Other measures

The use of an aggregated measure such as revenue facilitates measurement; however, does not
reflect the multi-output nature of PAs as productive units (Gonzalez and Truijio, 2009). The
further examine the source of output growth, annual tonnage growth is reported per port
across all major cargo markets served by each respective port. In addition, growth in tonnage
relative to overall market growth is also reported per port. To measure relative growth in
respective markets, we measure the percentage of which actual growth in a period is above
expected growth if the tonnage in the port grew at the same rate as tonnage growth in the
period. This measure is an adapted form of the shift-share analysis introduced by Notteboom
(1997) and, as such, is termed the ports shift share margin (percentage of actual growth above
expected growth):

\[ shiftsharemg_{im} = \frac{\left( tng_{imt_1} - \left( \sum_{i=1}^{n} \frac{tng_{imt_1}}{tng_{imt_0}} \right) * tng_{imt_0} \right)}{\left( \sum_{i=1}^{n} \frac{tng_{imt_1}}{tng_{imt_0}} \right) * tng_{imt_0}} \]  

(5)
Here $i$ represents port $i$ and $m$ represent the cargo mode. In this way, the shift-share margin is a normalised measure of growth relative to the market for each cargo market. A positive shift share indicates a relative growth in competitiveness of services running through the port. The shift-share analysis is examined over two periods: firstly, the pre-crash boom period from 2000 to 2007, and secondly the post-crash inclusive of the recessionary (2008-2013) and recovery periods (2013-2016).

### 3.4 Data sources
The above measures were constructed using data extracted from various sources. All measures of inputs, outputs and profitability were obtained from the audited financial accounts reported in the annual reports of the respective Port Companies with descriptive statistics reported in Table II. Data on the ten-year bond yields, the consumer price index and Gross Fixed Capital Formation deflator were obtained from the Ameco database. Port traffic statistics were obtained from Eurostat.

Qualitative sources used in the completion of the analysis include periodic policy reports; the annual industry statistical bulletin, i.e. the Irish Maritime Transport Economist (IMTE); and available corporate documents of the individual port companies (including a full series of annual reports and available master-planning documents).

### 4. Results
The findings of the case study are presented in four parts. Section 4.1 outlines the major macro-economic developments that have affected the port sector over the period. Section 4.2 outlines the major changes at an industry level. The purpose of both these sections is to outline the major external factors that have influenced performance over the period. Section 4.3 details the performance at the individual port level. This section reports the performance change using the metrics outlined in Section 3, and proceeds to construct an explanatory account of observed changes using qualitative sources. Section 4.4 summarizes the key findings and discusses the key drivers of port performance in the context of the major macro environmental and industry level changes that have affected the port sector over the period.

#### 4.1 Major macro-economic developments
The 2000-2016 period was characterised by pre-recession boom, a financial crisis beginning in 2007 and a subsequent economic recovery beginning in 2013 (Whelan, 2014). This pattern has translated to trade in international goods as represented in Figure 2. In terms of the structure of trade in the early 1980s and 1990s, the structure of Ireland’s merchandised exports shifted from low-value to high-value low-volume manufactured goods (Brunt, 2000).

As with most developed countries, this creates an imbalance in shipping terms because the volume of imports exceeds the volume of exports (despite the value of exports far exceeding the value of imports). This has largely been consistent over the period with euro per tonne ratios at an average of €8,000 per tonne for exports and €1,700 per tonne for imports. However, examining the tonnage imbalance following the crash, there has been a closing of the gap somewhat, with tonnage imbalance falling from 27 ml tonnes in 2007 to 20 ml tonnes in 2016, with the number falling as low as 17 ml tonnes in 2013. The export activity in volume and value terms has risen above pre-crash levels (up 30 per cent in value terms and 36 per cent). The rise in exporting activity is consistent with economic commentary on the recovery, which has been described as export-led. In contrast, imports in volume terms had not yet reached 2007 levels by 2016.
<table>
<thead>
<tr>
<th>Port</th>
<th>Mean Quantity of Capital (€ 000's)</th>
<th>Mean Cost of Capital (€ 000's)</th>
<th>Mean Labour (number of employees)</th>
<th>Mean Cost of Labour (€ 000's)</th>
<th>Mean Revenue (€ 000's)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dublin Port Company</td>
<td>€239,834</td>
<td>€40,718</td>
<td>216</td>
<td>€15,531</td>
<td>€66,723</td>
</tr>
<tr>
<td>Port of Cork</td>
<td>€95,565</td>
<td>€10,671</td>
<td>111</td>
<td>€8,180</td>
<td>€22,865</td>
</tr>
<tr>
<td>Shannon Foynes Port Company</td>
<td>€36,291</td>
<td>€3,526</td>
<td>48</td>
<td>€3,438</td>
<td>€10,765</td>
</tr>
<tr>
<td>Port of Waterford</td>
<td>€31,135</td>
<td>€2,398</td>
<td>40</td>
<td>€2,463</td>
<td>€8,269</td>
</tr>
</tbody>
</table>
4.2 Major industry (meso) changes

As displayed in Figure 3, the boom bust and recovery cycle largely translated to growth across the cargo market sectors in the Irish case. The exception to that is liquid bulk, which has seen steady decline. This market is largely driven by demand for petroleum products, which has decreased in line with changing consumption patterns and increased energy efficiency (SEAI, 2016). The cyclical pattern was most pronounced in break bulk. High prerecession growth in this market was largely fuelled by a sectoral boom in construction, which has been most strongly affected by the crash (Whelan, 2014). Dry bulk quickly recovered, reaching pre-recession highs in 2013. The dry bulk market is driven by input demand for the agri-food industry and large-scale industrial production.

The unitised sector (comprising of Roll on Roll off (RORO) and Lift on Lift off (LOLO) traffic) is more closely aligned with activity in the domestic economy. Here, contrasting recovery rates can be seen, with RoRo recovering at a much quicker rate than LoLo. This may be explained by two factors. Firstly, RoRo traffic is more closely aligned with trade with the UK, which was less affected by the recession. Secondly, there has been a redistribution of traffic from LoLo to RoRo. This is attributable to the introduction of a new hybrid “conro” service operated by Cobbelfret, a Belgian company that had previously

Source: Authors composition based on CSO data
operated LoLo services through its sister company C2C[6]. This service operates from Dublin to Zeebrugge and Rotterdam and directly competes with short sea and feeder LoLo services to the continent. When taken on a whole, total unitised traffic volumes have just returned to pre-crash in 2016 rising to 35.5 ml tonnes up from 35 ml tonnes in 2007.

Unitised traffic moves primarily from ports on the east and south coast. Examining the evolution of competitive dynamics in the RoRo sector first, there has been increased concentration over time. Traditionally, RoRo traffic has consisted primarily of trade with the UK (accounting for 90 per cent of total traffic in 2016, and 99 per cent in 2009, with the change mainly because of the Cobbelfret service outlined above). At the beginning of the period, Dublin was the market leader; however, it faced significant competition because of the mobility of RoRo traffic. Competition was strongest with Larne (24 per cent market share) and Belfast (24 per cent) in Northern Ireland and Rosslare to the south (10 per cent percent market share). However, following the recession, there was a large-scale restructuring and rationalization of existing routes and operators particularly on the primary UK–Ireland Corridors favoring the ports of Dublin and Belfast. Stena in 2013 transferred service from Dún Laoghaire to Dublin. In Northern Ireland, Stena Line transferred services from Larne to Belfast.

The LoLo sector has followed a similar pattern with increased concentration post-crash. At the beginning of the period, Dublin was also the market leader in LoLo traffic at 55 per cent at the start of the period, with sizeable traffic flows in Waterford, Cork and Belfast (17 per cent market share). There was de-concentration prior to the recession because of congestion at the larger ports. This trend reversed post-recession with the top three ports, i.e. Dublin (55 per cent) Cork (21 per cent) and Belfast (18 per cent), accounting for 94 per cent of the total market in 2016 up from 83 per cent in 2007. Similar to the RoRo market, there was a restructuring following a contraction of demand of almost 2 ml tonnes, which caused significant over-capacity in terms of port and carrier capacity. In response, carriers responded by rationalising routes and increasing the use of Vessel Sharing Agreements (VSAs) to improve utilisation rates. Murphy (2010) estimated that 14 routes were rationalised in 2009; however, by 2011, the three largest VSAs on the market accounted for 70 per cent of total market traffic (Murphy, 2013). The move toward VSA’s led to an increase in ship size and reduction in the number of calls as evidenced in Figure 4. Larger vessels and less frequent call favour the competitiveness of the larger ports. Firstly, there is greater depth available at the larger ports of Dublin, Belfast and Cork. Secondly, given their location, they have greater proximity to the larger hinterland markets they have a better potential for achieving utilisation of larger vessels (O’Connor et al., 2018).

In the bulk sector concentration, trends in liquid and dry bulks have followed that of the unitised sector. In both sectors, similar to Lolo, there has been an increase in the size of

![Figure 4](image-url.png)

**Figure 4.** Change in LoLo Vessel Profile

**Source:** Authors composition based on Eurostat data
vessel used as displayed in Figure 5. Noticeably, the break bulk sector has become deconcentrated. Vessel sizes in this sector tend to be smaller; therefore, they are possibly better suited to regional ports. In addition, break bulk cargos typically consume a relatively large amount of land space within ports; thus, given competition from other modes, break bulk may be deprioritised. This is the case in Dublin as per the ports masterplan ports “break bulk, which is the most land intensive cargo mode, has largely disappeared from Dublin Port due to unitised trade and use of smaller east coast ports”.

4.3 Port level performance changes

4.3.1 Dublin port company. TFP growth in the pre-crash period was staggered. Initially, TFP fell, largely driven by a reduction in the output index, with TFP dropping to a low of 79 in 2002. Subsequent to 2002, TFP began to recover as a decline in the input index was matched with an increase in output with TFP peaking at 108 in 2006. There were two major factors influencing TFP change over the period. Firstly, the port implemented a series of reforms in the early part of the decade to reduce operating costs by withdrawing from the provision of non-core services, mainly warehousing and crane operations. As reported in the annual reports, non-core service provision had become loss-making activities and withdrawal from such activities in a programme of modernisation was intended to allow the port to focus on developing infrastructure. This represented a further move toward the landlord model because the port replaced the PA provision of these services with a system whereby private third parties compete to provide these services (Figure 6 and Table III).

The major effect of these reforms was a reduced level of staffing with the PA employees dropping from 416 in 2000 to 208 in 2006, i.e. a drop of over 50 per cent. The shift in business model appears to have been highly successful in terms of allowing for a focus on capital investment. In 2000, labour costs accounted for 48 per cent of total input shares; however, by 2011, at the height of the recession, input shares accounted for 18 per cent of total input shares. Further, after 2008, capital accounted for approximately 80 per cent of total input costs every subsequent year, up from just over 50 per cent at the turn of the millennium. The port has thus been able to significantly increase the capital stock (up 66 per cent over the period) while keeping its overall input shares constant.

The second major factor affecting TFP growth in the pre-crash period was a loss in revenue because of the movement away from non-core activities and an initial loss of market share in the LoLo market because the port suffered from the effects of congestion. There was a significant loss of volume in 2001 where LoLo traffic declined by from 4.2ml tonnes to 3.3ml tonnes in 2000. Traffic volume did not recover to 2000 levels until 2005.
coincided with growth in all other ports in the network, resulting in Dublin Port’s market share dropping from 54 per cent in 2000 to 45 per cent in 2005. However, this trend had begun to reverse in the years immediately prior to the recession with Dublin’s market share recovering to 51 per cent in 2007 because of an expansion of routes through Dublin and increase in capacity in two of the ports’ three terminals. Coupled with the recovery, the port saw the continued rise of RoRo traffic through the port. This continued a trend that began in the 1990s as Dublin Port won a market share from the major ports in Northern Ireland (Brunt, 2000).

Change in the TFP index following the crash followed a similar trajectory to change in the index pre-crash. This involved an initial decline, followed by a gradual increase with TFP peaking at 1.13 at the end of the period. TFP index change was largely driven by an increase in output with the input index constant over the period. Initially, output declined given the effect of the financial crisis but it subsequently recovered. Growth in the most recent periods was driven by the RoRo sector, with the port benefiting from increased concentration in the market and the success of the ConRo service. There were also increases in market share in the LoLo and liquid bulk sectors over the period.

Profitability, as measured by the operating margin, showed stronger growth in the post-crash period than the pre-crash period. This is despite revenue only returning to pre-crash levels in 2014. Furthermore, after examining the port company accounts, led to an indication as to what caused this rise in profitability rate. Initial improvement in the profitability rate was driven by a lower cost of sales, which fell owing to rationalisation within the company.

Table III.

Dublin Tonnage growth

<table>
<thead>
<tr>
<th>Traffic Sector</th>
<th>Tonnage 2000 (Mrkt share)</th>
<th>Tonnage 2016 (Mrkt share)</th>
<th>Shift Share Margin 2000-07 (%)</th>
<th>2008-16 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RORO</td>
<td>6,536 (35%)</td>
<td>12,667 (48%)</td>
<td>14</td>
<td>21</td>
</tr>
<tr>
<td>LOLO</td>
<td>4,176 (54%)</td>
<td>5,062 (55%)</td>
<td>-5</td>
<td>7</td>
</tr>
<tr>
<td>Dry Bulk</td>
<td>1588 (11%)</td>
<td>2053 (13%)</td>
<td>27</td>
<td>-14</td>
</tr>
<tr>
<td>Liquid Bulk</td>
<td>3342 (24%)</td>
<td>4017 (36%)</td>
<td>19</td>
<td>16</td>
</tr>
<tr>
<td>Break Bulk</td>
<td>250 (16%)</td>
<td>50 (4%)</td>
<td>4</td>
<td>-72</td>
</tr>
</tbody>
</table>

Source: Authors own composition
with the cost of sales to revenue ratio dropping from 50 to 34 per cent from 2000 to 2007. This ratio, however, has been stable and averaged 33 per cent percent from 2008 to 2016. The major driver in the operating margin in the subsequent years has been a decrease in admin and exceptional costs, which dropped from 25 per cent of total revenue in 2007 to 13 per cent in 2016.

4.3.2 The port of Cork. There was limited change in the TFP index in the port of Cork for the pre-crash period. While there was growth in output, it was closely matched by growth in the input index. This is largely explained by a rise in input consumption because the port underwent a period of capital expansion coupled with a period of rising labour costs. Most significantly, the port had a net investment of 22 ml in 2004 because it net purchased land at the former Buckeye manufacturing facility adjacent to the ports Ringaskiddy Terminal (Figure 7 and Table IV).

In the immediate aftermath of the crash period, TFP fell significantly and hit a low of 86, with a 16 per cent drop in output in 2009. Subsequent to 2009, the ports TFP gradually recovered driven by a reduction in the ports input index and recovery in output. Influencing this was dock labour reform initiated in 2009, which improved competitiveness in the LoLo sector. The port bought out the pre-existing causal labour force and assumed responsibility for stevedoring (through the ports subsidiary Cork Port Terminals Services). Finally, TFP has increased significantly in the most recent periods following the integration of what was Bantry Bay Port Company into the auspicious of the Port of Cork Port Company in 2014.

![TFP and Profitability Change](image)

**Source:** Authors own composition

<table>
<thead>
<tr>
<th>Traffic Sector</th>
<th>Tonnage 2000 (Mrkt share)</th>
<th>Tonnage 2016 (Mrkt share)</th>
<th>Shift Share Margin 2000-07 (%)</th>
<th>Shift Share Margin 2008-16 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RORO</td>
<td>191 (1.01%)</td>
<td>84 (0.3%)</td>
<td>-64</td>
<td>72</td>
</tr>
<tr>
<td>LOLO</td>
<td>988 (14%)</td>
<td>1,889 (23%)</td>
<td>15</td>
<td>39</td>
</tr>
<tr>
<td>Dry Bulk</td>
<td>1556 (11%)</td>
<td>1,435 (9%)</td>
<td>3.00</td>
<td>-19</td>
</tr>
<tr>
<td>Liquid Bulk</td>
<td>6365 (46%)</td>
<td>5,430 (48%)</td>
<td>-4</td>
<td>7</td>
</tr>
<tr>
<td>Break Bulk</td>
<td>651 (41%)</td>
<td>139 (10%)</td>
<td>-63</td>
<td>-36</td>
</tr>
</tbody>
</table>

**Table IV. Port of Cork tonnage growth**

**Source:** Authors own composition
Accordingly, in 2015 and 2016, the ports output and input indexes step changed, reflecting its expanded operations.

Profitability at the start of the period as reported in the annual accounts was artificially high because of a failure to account for an administrative expense that was accrued in subsequent years. Therefore, 2001 acts as a better base from which to compare the change in profitability for the port company in the period. The Port maintained a steady operating margin prior to the financial crisis despite rising operating costs (increased 51 per cent between 2000 and 2007). Following the recessionary period, the port’s profitability dropped, corresponding to a drop in output. As revenue has increased, however, the ports profit margins have not grown accordingly. This related to an increase in operating cost over the pre-recessionary period (with the cost sales ratio in 2014 at 65 per cent versus 54 per cent in 2007).

Examining the output mix of the port may provide a clue to why this has occurred. At the start of the period, the port was seen as a specialist liquid bulk port (Brunt, 2000). Gradually, the activity in this category declined as the container business has become increasingly important for the port. In addition, dry bulk activity has declined over the period with its overall market share dropping to 2 from 9 per cent in 2016. This drop in the market has been largely in the last number of periods because the port has suffered a decline in exports owing to a cessation of the exportation of minerals. Profit per euro of revenue generated in the LoLo sector is likely to be lower than the bulk sector owing to the public rather than private stevedoring and the additional costs of labour.

4.3.3 Shannon Foynes Port Company. Shannon Foynes Port Company was the last port in the sample and was formed as an amalgamation of previously separate harbor companies responsible for the various sites along the Shannon Estuary. The previous entities had run into financial difficulty, which was reflected in the negative operating margin at the start of the period. The port returned to profitability in 2003 and continued to run profits in the build up to the recessionary period. Similar to Dublin and in contrast to the other ports in the sample, the port’s profitability rose rather than declined in the recessionary period. The growth rate in profitability has continued to increase with the operating margin peaking in the last period at 35 per cent (Figure 8).

TFP has similarly risen over the period. In the run up to the recession, this was mainly attributable to rising outputs as inputs remained stable between 2000 and 2008. Notably, there is a strong divergence between profitability and TFP growth in 2006. TFP is measured at a peak of 80 per cent over the base period owing to growth in revenue to over 16 ml euro. In contrast, the operating margin dropped to 6 from 16 per cent in 2004. Referring to the annual reports much of this sudden rise is attributed to the launching of a LoLo service,

**Figure 8.**
Shannon Foynes TFP and Profitability Change

**Source:** Authors own composition
which the port was actively involved with running. This rise in income is subsequently matched by exceptional costs again, attributed to the launching of the LoLo service and court cases the port was engaged with at the time. Such exceptional costs, while effecting profitability, do not factor into the input index.

Aside from this anomaly, TFP growth largely mirrored that of profitability with consistent increases from 2010 to 2016. This increase in TFP has been driven by both growth in output and rationalisation in inputs. Much of the ports business is related to large industrial clients and sector specific production, particularly agriculture. Therefore, it is possible that the ports output level was less affected by the downturn in the domestic economy than in other ports, which largely serve markets more closely related to domestic consumption. Rationalisation of input began in 2007 with the initiation of a programme to improve manning efficiency, including a scheme to introduce annualised operating hours to increase working flexibility. This process accelerated during the recessionary period, with the ports input index reaching a low of 80 per cent of base value in 2014. Subsequent to this, in the last two years of the period, there has been an increase in input consumption as the port has begun its most significant programme of capital expenditure over the period.

Output growth over the period has largely been driven by dry bulk traffic, as evidenced in Table V. In examining traffic patterns traffic in Shannon Foynes, it is important to segment between traffic serving single user large-scale industrial clients with processing sites along the Shannon estuary and bulk traffic that serves demand that occurs in the immediate hinterland at multi-user terminals in Foynes and Limerick. Evidence from the ports corporate documents allows us to examine the evolution of traffic in the two categories at varying points in time. As per the 2007 annual report peak, traffic at the port reached 11.35 ml tonnes, of which 2.4 ml tonnes (approximately 21 per cent) were handled at multi-user terminals. In 2011, during the recessionary period, at the time of the ports master planning exercise, traffic had declined 9.9 ml tonnes of which 1.66 ml tonnes (approx. 17 per cent) were handled at multiuser facilities. Finally, in 2016, traffic volumes increased to 11.1 million tonnes of which 2.4 ml tonnes (approximately 22 per cent) were handled at multi-user facilities.

4.3.4 Port of Waterford. Waterford Port Company, in direct contrast to the position of Dublin, decided to assume responsibilities for container operations at the newly developed Bellview Container Terminal at the start of the period. In the run up to the recessionary period, this move was initially very successful. Between 2000 and 2008, the ports output grew 112 per cent, largely driven by an increase in container volume and subsequent revenues from port dues and terminal handling charges (container volumes peaked at 1.3 ml tonnes in 2007 up from 1 ml tonnes in 2000). The ports input index over the same period was subject to a step change as expected; however, the rise in input consumption was more modest at 55 per cent, enabling overall TFP to increase by 56 per cent. This strong performance was reflected in the port’s profitability with the ports operating margin rising to 46 per cent (Figure 9 and Table VI).

<table>
<thead>
<tr>
<th>Traffic Sector</th>
<th>Tonnage 2000 (Mrkt share)</th>
<th>Tonnage 2016 (Mrkt share)</th>
<th>Shift Share Margin 2000-07 (%)</th>
<th>2008-16 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Bulk</td>
<td>8,230 (57%)</td>
<td>9,714 (61%)</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>Liquid Bulk</td>
<td>1,903 (14%)</td>
<td>1,050 (9%)</td>
<td>-22</td>
<td>-16</td>
</tr>
<tr>
<td>Break Bulk</td>
<td>150 (9%)</td>
<td>184 (13%)</td>
<td>58.00</td>
<td>-2</td>
</tr>
</tbody>
</table>

Source: Authors own composition

Table V. Shannon Foynes tonnage growth
As outlined, the effect of the recession and changing structural demand conditions particularly affected the container trade through Waterford, with container traffic dropping from the high of 1.3ml tonnes in 2007 to a low of 268ml tonnes in 2014. Prior to the recessionary period, LoLo volume was served by seven weekly services: four by operator C2C and 3 by DFDS. C2C subsequently pulled out of the port and consolidated its operations through its sister ConRo service in Dublin. DFDS reduced the number of services to two operated on a VSA with Samskip. Initially, the port struggled to readjust inputs to account for the fall in output level, with TFP and profitability being significantly affected. Most recently, however, the port has been able to decrease its cost base with inputs dropping from 1.53 in 2008 to 1.2 in 2013. In addition to a rationalisation in the consumption of inputs, there has been a rise in output in recent years driven by a rise in dry bulk traffic with a shift share of +37 per cent in the post recessionary period. These developments have led to an increase in TFP and return to positive profit margins for the port company since 2013 (note the high operating margin of 2013 is attributable to exceptional income accrued to the port company).

4.5 Summary of findings
The key findings and identified drivers of performance are summarised below.

**Key Policy Drivers:**

1. 1996-2000 Commercialisation introduced with passing of the Harbours Act; and
Key Macro Environmental Drivers:
(1) 2000-2007 is characterised by a pre-crash boom period;
(2) 2008-2013 is characterised by a financial crisis and recessionary period; and
(3) 2013-2016 is characterised by a subsequent economic recovery.

Key Meso Level Drivers:
(1) Unitised Sector (RoRo and LoLo):
   - Growth follows wider macro-economic trend with pre-financial crash growth, decline and subsequent recovery in both LoLo and RoRo. Recovery is stronger in RoRo primarily because of the commencement of new “ConRo service.”
   - Increased concentration in traffic across ports in both sectors with large-scale consolidation of the number of services across operators.
   - Trend toward the use of larger vessels and Vessel Sharing Agreements in the LoLo sector.

(2) Bulk Sector (Liquid, Dry and Break Bulk):
   - Growth in break and dry sectors largely follow wider macro-economic trends with pre-financial crash growth, decline and subsequent recovery, and gradual decline in the liquid bulk sector.
   - Increased concentration across the Dry and Liquid Bulk sectors with a trend toward increased vessel size.
   - Decreased concentration in break bulk sector.

Key Drivers of Port level Performance:
Dublin Port Company.
(1) Pre Financial Crash:
   - Staggered TFP growth overall with an initial loss driven by output reduction because of lost revenue owing to a change in business model and subsequent divesture in operational activity and a loss in traffic in the LoLo sector.
   - Subsequent recovery and growth in TFP driven by input reduction because of the change in business model and movement toward the full landlord model. There was also strong growth in RoRo traffic over the period and a recovery and growth in the LoLo following the initial loss of market share.

(2) Post Financial Crash:
   - TFP growth also staggered post-crash with TFP change largely driven by the output index with the input index remaining relatively stable over the period. The output index initially declined because the effect of the financial crisis and subsequently recovered because of recovery and growth. Growth was strongest in the RoRo sector because the port benefitted from increased concentration.
   - A large increase in the profitability rate because of the port benefitting from a reduced cost of sales to revenue index from 2000 to 2007 and subsequently a large decrease in admin and exceptional costs from 2008 to 2016.

Port of Cork:
(1) Pre Financial Crash:
   - Limited growth in the TFP index as a rise in the output index was matched with rising input because of an increase in labour costs and significant capital investment. The profitability rate was also largely stable.
After examining the effect of macro-environmental level drivers first, as would be expected, performance in the sector was cyclical and closely related to the underlying Irish economic business cycle. This is clearly demonstrated by the close correlation between network traffic and TFP growth, as shown in Figure 10.

However, across the ports, there was a divergence in the effects of the major macro environmental changes. This is particularly apparent when the performance is compared before and after the recessionary period. All four ports saw decreased performance after 2007; however, the duration of the decline and subsequent recovery is different across the port. Shannon Foynes Port Company returned to 2007 productivity levels in 2013. The ports of Cork and Dublin returned to 2007 levels in 2015. Finally, the port of Waterford is still 23 per cent below 2007 levels of performance when measured in terms of productivity change.

The varying rates of recovery in the respect ports have likely been affected by the longer term meso level trend toward concentration in the major cargo markets. This is most clearly illustrated when examining productivity change in Dublin and Waterford over the period as both ports had similar growth trajectories preceding the recession. Pre-recession both ports experienced similar increases in productivity, as the output of the port grew through increases in unitised trade. In addition, both ports had increased capacity through capital investment. Post-crash, however, the shift in demand and acceleration in the centralisation process favoured Dublin and greatly worked against Waterford. Dublin Port, in the
post-crash period, managed to grow its output largely through attracting new services in the RoRo sector while keeping its cost base low; hence, its productivity grew significantly. In contrast, the port of Waterford saw its throughput fall unexpectedly. The port suffered a significant fall in productivity in the immediate years following the crash as it took a number of years to adjust its input consumption. Subsequently, the port has managed to recover its productivity somewhat as both its input level had reduced, and the growth in Dry Bulk business substituted to some degree for the loss in its LoLo business.

Focusing on the initiatives of managers, a notable driver of performance has been a trend toward rationalisation of labour across the ports. In Dublin, this began at the beginning of the period as the port moved to divest itself from non-core operating activities. In the Port of Shannon-Foynes and Cork, there were dock labour rationalisation schemes aimed at improving the competitiveness of port services. In the Port of Waterford, a rationalization in response to the loss of business has allowed the port to recover from a difficult period. There have thus been active attempts on the part of the major companies to control the cost base of operations.

A second managerial initiative that has driven performance is the degree to which operating activities are outsourced to the private sector. In the bulk sector, the operating structure used across the ports closely followed that of the landlord model with mainly private provision of stevedoring. In the unitised sector, however, there was a divergence between Dublin, which moved closer to the Landlord model, and the ports of Cork and Waterford, both of which fully assumed responsibility for terminal operations. This appears to have had an effect on productivity. In Dublin, after the initial change in business model, increases in scale were largely unmatched by the input index. In contrast, increases in unitised trade in Waterford (pre-crash) and Cork have been matched by increases in the input index. This difference points toward differing marginal returns to scale depending on the model that has been used. In the landlord model, the effective outsourcing of operations to the private sector reduces the marginal cost of additional output (with the exception of expansion that requires capital investment). In the public provision model, the port company potentially has scope for greater returns based on its capacity to charge for the full terminal handling service; however, the port company faces the full additional cost of providing services in labour.

The divergence in operating model activity is mainly attributable to scale of operations as outlined in the competition authority report (2013). Dublin operates at a higher volume

![Figure 10. Network TFP and Profitability Change](359)

Source: Authors own composition
than the other two ports and, as such, sustainably manages to maintain a number of separate terminals. The reduced scale of the LoLo business in the smaller ports is viewed to impact the commercial feasibility of having more than one operator provide services from the port. Private participation in a single operating terminal runs the risk of the creation of a private monopoly. Without the regulating force of intra-port competition, it is feared that private monopolies with little commercial incentive to invest and innovate will produce poorer quality services. Discussing this directly, the port of Cork outlines that the ‘challenge for the port sector arises from the fact that the sector is small in scale, scope and profitability, and there is little benefit or attraction for the private sector to invest in local facilities’. Port Company provision, therefore, mitigates this risk and helps ensure quality of service.

4.6 Policy implications and conclusions

4.6.1 Policy implications. The purpose of the initial reform in the sector, as outlined in Section II, was to create commercially responsive port companies. It is difficult to say with certainty whether the reforms were successful without access to data regarding the performance of the ports prior to reform or an adequate counterfactual of sample of non-commercialised ports to compare Irish performance with. There is, however, evidence of responsiveness on the part of the ports, which would suggest some degree of success. Across the ports, there was labour rationalisation in an effort to improve efficiency. In addition, all ports sampled showed a responsiveness to recover from the negative effect of market contraction because of the recession. Lastly, net investment is easily derived from the change in capital stock and can be seen, as shown in Figure 11. Here, it can be seen that there was positive investment across all ports over the period.

NPP 2013 represented a departure from the previous policy position through a move to concentrate state support in the largest ports. The decision to tier the ports in National Ports Policy (2013) appears to be largely consistent with meso level dynamics toward concentration and performance of the largest ports. The tier 1 ports appear to be better positioned both in terms of access to deep water and financial resources to develop capacity in line with changing trends. As outlined in the Introduction, ports require sustained traffic flows to make the necessary capital investments to remain competitive. The market for port services in Ireland is limited by the size of the Irish hinterland and relative peripherality of Irish ports to the major trade lanes, which makes it unsuitable for transhipment traffic. There is a strong case to be made that, with limited traffic, there is not a sizeable enough

![Figure 11. Net Investment Across Sampled Ports](image-url)

Source: Authors own composition
market to support multiple competing ports. The increasing concentration in all sector except break bulk would support this conjecture. In addition, in Figure 10, it is clear that Dublin port has invested far more over the period than any other port.

Looking to the future, land constraints in Dublin Port may potentially limit future development of the port at its current city centre location. Given the importance of the port, this poses a threat to future development of the port system. Traditional port system development models point to limits to concentration (Notteboom and Rodrigue, 2005). For example, Notteboom and Rodrigue’s (2005) popular framework suggests that as central ports continue to expand, space constraints lead to diseconomies of scale leading to a period of de-concentration. While there may not be immediate concern regarding space constraints in the long term, this may become an issue. A growing gap in size and performance between the large and small ports creates doubts as to whether smaller ports may be able to adequately develop to provide substitute capacity should capacity constraints occur in Dublin. One potential may be amalgamating ports as proposed by the Report of the Review Group on State Assets and Liabilities. Here, it is proposed that ports are amalgamated into three port companies representing east, south and west coast ports.

5. Conclusion
By applying a case study approach, this paper provides a descriptive account of the evolution of performance change throughout the Irish Port system over the 2000-2016 period. In this way, the paper provides the first review of Irish port performance in the academic literature since Mangan and Cunningham (2000). It is clear from the analysis that performance was majorly effected by the macro-economic changes of the 2000-2016 period. Through the in-depth case study, it was possible to identify how port management adapted in respect to the short term shock of an unexpected reduction in traffic after a period of unprecedented growth. Clearly, the impact of the recession was divergent across the ports largely because of the scale and nature of operations of the respective ports. This has had an effect on the actions taken and rate at which productivity has recovered. A longer-term trend at the meso level toward concentration in traffic volumes appears to further favour the performance of larger ports. As identified, a growing gap in performance between smaller and larger ports creates a potential issue for the future development of port infrastructure should space constraints become an issue at the most dominant ports.

There are, however, several limitations to the study. As outlined in the methodology, the productivity measures used restrict the analysis to relative change in productivity over time in individual ports. This was largely motivated by the small and heterogeneous available sample. In future studies, the use of frontier methods to measure productivity may enrich the analysis. Similarly, the study does not measure all aspects of port performance. The effectiveness of service delivery and environmental performance are increasingly important in port performance studies (Brooks and Pallis, 2008; O’Connor et al., 2016). Historical data to measure the performance on such dimensions was not available for this study. In future studies, including such measures would further enrich any future performance analysis.

From a policy evaluation perspective, the results show the importance of contextualising the effects of macro-environmental changes and demand-side dynamics when considering supply-side performance factors. It is argued that the study demonstrates the potential of in-depth case study analysis for uncovering insights into the drivers of performance across a number of dimensions, thus allowing for the contextualisation of results. The study of a small number of cases enables the use of rich qualitative sources to create strong narratives that combined with quantitative measures of performance can lead to new insights. Recently, this form of case study
approach has been used to examine performance in a number of other sectors including energy (See and Coelli, 2013), food production (Palcic and Reeves, 2015) and airports (Cahill et al., 2017). It is proposed that this form of approach has particular potential for use in conjunction with large sample studies that are more typical in the port performance literature. Here, case studies can be used to generate insights and propositions that can be more formally examined in large sample studies.

Notes
1. The act was largely amended in 2000
2. Rosslare falls under a different governance system because of an historical arrangement whereby the port is a part of the state rail company Iaranoid Eireann.
3. Labour costs were converted to constant prices using the consumer price index with 2000 as the base year.
4. Real capital stock was calculated by taking the deflated nominal capital level in the vesting year. The gross fixed capital formation deflator was used to convert capital to constant prices with 2000 as the base year. To account for different asset classes, two groups of assets were formed, land, terminals and quays, which were depreciated at 3 per cent followed by plant and equipment, which was depreciated at 12 per cent.
5. Revenue was also converted to constant costs using the consumer price index with 2000 as the base year.
6. This service involves the movement of stackable containers that are driven onto specialised vessels using maafi trailers and is termed colloquially as ‘ConRO’.

References


MABR 4,4


Further reading


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The regulations of shipping conferences in Taiwan referring to the EU to repeal the block exemption for liner conferences

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Abstract

Purpose – The first well-known liner shipping conference was created for the UK/Calcutta trade in 1875. However, the European Union (EU) decided to abolish repeal the liner conferences system with effect from October 18 2008. This paper aims to study the governing regulations on shipping conferences in Taiwan along with investigating the impact on the EU to repeal conferences. The regulation on liner conferences in the USA is also briefly referred.

Design/methodology/approach – Literature review and questionnaire survey are used to conduct the study. This paper reviews important literature relating to the EU to repeal the conferences system and its impact on liner market competition to/from European trade routes, with discussions on the US and Taiwan regulations on shipping conferences. Questionnaire survey data, collected from published report and this research present shippers’ and carriers’ responses on the changes of regulations on liner conferences.

Findings – Shippers are strongly supporting the repeal of the conferences system. Academic research results basically reveal that the liner market will be more competitive in the trades to/from the USA and the EU after the repeal of the conferences. For Taiwan, its regulations are rather simple and loosely control over the liner conferences; therefore, if the shipping administration intends to enhance the inspection of the agreements of conferences and strategic alliances, more detailed regulations should be prepared, and the provisions of the EU or USA would be a good reference.

Practical implications – Through the discussions on the legal treatments of shipping conferences from the USA, the EU and Taiwan perspectives, this paper provides shipping researchers with not only a clear evolution of the liner conferences but also a deep understanding of the impact to repeal the conferences on liner market competition.

Originality/value – This paper reviews important literature and related legislations on liner conferences including the USA, the EU and Taiwan. The different responses on the EU to repeal the conferences system from shippers and carriers are discussed. The impact on liner market competition is presented.

Keywords European union, EU, Taiwan, Regulation 4056/86, Liner conferences, Block exemption

Paper type Research paper

1. Introduction

Coalition operation strategies have been common in the liner shipping industry. The cooperative mechanism has been evolved over the past centuries. Many types of mechanisms have been used by ocean transport industry to do business cooperatively or to limit competition. The traditional organization is liner conference. The others are
An association of competing liner owners engaged in a particular trade who have agreed to limit the competition existing among themselves. As a minimum, they will have agreed to charge freight rates or passenger fares for each class of traffic according to an agreed schedule of charges and to show no discrimination between shippers. To the agreement foregoing all forms of price competition may be, and usually is, added an agreement to regulate sailings according to a predetermined pattern and to recognize the berth rights of other members. A further step may be to add a full pooling agreement under which profits and losses on the trade covered by the conference are shared between the member lines.

It is well known that the first successful shipping conference was the “Calcutta Conference,” which was created for the UK/Calcutta trade in 1875 (Blanco, 2007). A consortia can be defined as “specialized joint ventures encompassing many different arrangements.” The organizational structures and commercial scope of consortia are many and varied. As shown in Table I, consortia agreements range from joint scheduling to equity joint venture. The consortium originated from the UK in the mid-1960s, and only conference members joined its operation. Latterly, consortia operation took place in both conference and independent camps in the 1990s. At the end of 1980s, a kind of new-cooperative mechanism in liner shipping, stabilization (or discussion) agreement emerged; after that, strategic alliances were born and mushroomed subsequently.

The reason for creating liner conferences was to restore profitability and control predatory and cut-throat competition in liner shipping. In the latter half of the 1800s, the widespread introduction of steam propulsion greatly increased the effective supply of shipping services; then, fierce competition took place out of excess capacity. Many factors jointly determine how a conference operates, such as the amount of tonnage on the route and the relative strength of each company, quantity and type of cargo on the route, variety of nationalities involved, length of the route and government’s intervention (Herman, 1983). A consortium is a means to help carriers to raise capital and to operate on a larger scale than before. In other words, through consortia arrangements, an individual carrier may enjoy increasing service frequency and extending port coverage while requiring no more investment on ships. Besides, consortia measures can help maximize asset utilization and help spread the risks of having to add/reduce capacity in line with changing market conditions. Regarding stabilization agreements, most of them positioned themselves as a bridge for both conference and non-conference carriers to discuss common issues of liner business environment, and then try to reach some kind of agreement in view of overcoming liner services operation difficulties (Midoro and Pitto, 2000). Shipping alliances, which can

<table>
<thead>
<tr>
<th>Types of agreements</th>
<th>Main characteristics</th>
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<tr>
<td>Joint scheduling</td>
<td>Minimal cooperation</td>
</tr>
<tr>
<td>Deck chartering</td>
<td>Container/bulk combination</td>
</tr>
<tr>
<td>Slot chartering</td>
<td>Piggy-backing</td>
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<tr>
<td>Vessel sharing</td>
<td>Space sharing</td>
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<tr>
<td>Equipment/chassis-sharing</td>
<td>Equipment sharing</td>
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<tr>
<td>Cost pooling</td>
<td>Cost equalization</td>
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<tr>
<td>Joint venture</td>
<td>Single marketing</td>
</tr>
</tbody>
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Table I. Types of consortia agreements

Source: Chiu (1996)
be loosely referred to a cooperative operational agreement between two or more liner carriers, are another rational responses to practical problems faced by the ocean shipping industry (Tang and Sun, 2018).

Because of the European Union (EU) officially repealed the block exemption for liner shipping conference on October 18, 2008, it marks a big change of regulatory body’s thinking and attitude toward to cooperation mechanism of liner shipping. Thus, this paper aims to study the governing regulations on shipping conferences in Taiwan along with investigating the evolution of EU competition block exemption for shipping and the impact on the EU to repeal conference system; in addition, am empirical study is conducted to present carriers’ opinions responding to the EU repealing the conference system. The organization of this paper is as follows. First, a short introduction of the shipping conferences is presented. Then, the reasons why the shipping conference is existed for more than 130 years are reviewed. Section 3 of this paper will discuss the shipping conference under EU antitrust law. Fourth, we investigate the responses from the industries, including those opinions from shippers and carriers. Fifth, the regulations and carriers’ opinions on shipping conference are explored. Finally, a conclusion and discussion are presented.

2. The opinions to support and oppose liner conferences

The existence of shipping conferences, which are among the earliest cartels in international trade (Marx, 1953), has always been a controversial issue. However, there has been no consensus in theory and practice, despite a pile of literature discussing on this topic. Table II presents those opinions that are for and against the conference system. Indeed, liner conference was scrutinized by political entities in Europe and North America in 1900s. The most often quoted official investigations are: the 1906 Royal Commission on Shipping Rings (RCSR) of the UK, the 1912 Alexander Committee of the USA and the 1967 Committee of Inquiry into Shipping (which is often called “the Rochdale Committee”) of the UK. All the official investigations did not immediately decide to eliminate the conference system from the liner shipping market, although there were some different opinions between them (Chiu, 1996).

The majority report of the RCSR made the following recommendations: the advantages of the conference system, including deferred rebates, were great; and the conferences did not enjoy excessive power in their markets; if such a situation was to arise, it could and must be prevented to avoid abuses. The report also cited in particular three limits on the

<table>
<thead>
<tr>
<th>Support</th>
<th>Oppose</th>
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<tr>
<td>1. It provides a stable, regular and coordinated services</td>
<td>1. It artificially raise freight rates by restricting competition and overriding market forces</td>
</tr>
<tr>
<td>2. It controls capacity efficiently and, thus, minimizes costs</td>
<td>2. It induces commercial inertia by protecting the most inefficient members</td>
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<tr>
<td>3. It covers the whole trade, including uneconomic cargoes and locations</td>
<td>3. It is bureaucratic, costly and unresponsive to change</td>
</tr>
<tr>
<td>4. It maximizes trade potential by cross-subsidization of cargo</td>
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</tr>
<tr>
<td>5. It offers stable freight rates which permit shippers to make forward sales with confidence</td>
<td></td>
</tr>
<tr>
<td>6. It offers security to carriers for capital investment</td>
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Source: Drewry Shipping Consultants (1991), pp. 17-18
monopolistic power of the conferences: first, the outside competition of tramps and independents; secondly, the inside competition between conference members in the provision of facilities and service, and sometimes even the quoting of rates; and thirdly, the common action taken by shippers (Marx, 1953, p. 62). The majority report continued recommending the publication of tariff and provision for collective bargaining with recognized shippers’ council. The minority report, however, favored more rigorous scrutiny on conferences from the Board of Trade and Parliament (Great Britain, 1909, pp. 114-6).

The Alexander Committee, in general, supported conferences as a necessary means of regulating competition to avoid the wastefulness of the price wars; however, the committee also acknowledged that conference system was an organization with some monopoly power and was convinced that “all monopolies are liable to abuse” (United States, 1914, p. 108). With respect to foreign trade of the USA, the committee proposed the following measures for eliminating the abuses and disadvantages which were inherent in conferences through effective government control:

- agreements between shipowners, and all matters relating to the control of freight rates, should be subject to supervision by the Interstate Commerce Commission (ICC);
- all agreements, understandings or conferences, and modifications thereof, should be registered and filed with the ICC, which should be empowered to order their cancelation in whole or in part whenever they were found to be discriminatory or unfair or detrimental to the commerce of the USA;
- rebates on freight rates and other discrimination between shippers should be made illegal;
- the ICC should be empowered to investigate complaints regarding, inter alia, the unreasonableness of rates and discriminatory practices and to commence proceedings on its own initiative in such cases;
- the use of “fighting ships” and deferred rebates should be prohibited in both the export and the import trade of the USA, and carriers should be prohibited from retaliating against shippers for any reason; and
- adequate penalties should be established to correct and prevent the abovementioned abuse (Alexander Report, 1914, pp. 419-21), cited by Marx (1953, pp. 65-66).

These suggestions were enacted into law in the Shipping Act of 1916, which allowed the formation of open conference, but outlawed the malpractices in the conference system such as fighting ships, deferred rebates, retaliation against a shipper for any reason by refusing or threatening to refuse shipping space and unfair or discriminatory contracts with shippers.

Compared to the above two enquires, the Rochdale Committee was more strongly in favor of the conference system. It concluded that “the ‘closed’ conference with fully rationalized sailings therefore appears to us most likely to serve the best interests of both shippers and shipowners.” (Great Britain, 1970, p. 132) At that time, those British gentlemen were also convinced that:

[...] the ‘open’ conference appears least likely to serve the interests of shippers. It is also least likely to serve that of shipowners; in their evidence to us they agreed that such a conference agreement typically resulted in low factors, low profits, and rising freight rates (Great Britain, 1970).

According to a recent study, Tang and Sun (2018) pointed out that shipping conferences and alliances are a kind of anti-competition conducts in liner shipping.
3. Shipping conferences under European Union competition law
Under normal circumstances, a liner conference is a kind of business cartel and should be regulated by antitrust laws (in the USA) or competition rules (in the EU). However, liner conferences have enjoyed the so-called block exemption from competition regulation in considering the special characteristics of liner shipping services. Because of the amendment of the EU competition law, the previous Articles of 85 and 86 of the Treaty of Rome were replaced by Articles 81 and 82 treaty establishing the European community (TEC); again, with effect from December 1, 2009, Articles 81 and 82 TEC have become, respectively, Articles 101 and 102 treaty on the functioning of the EU (TFEU) (European Commission, 2012). For the convenience of writing, this paper will cite these articles interchangeably as they then were used.

3.1 European Union competition rulings on liner conferences
Articles 81 and 82 TEC laid down the EU competition rules for all business sectors; Article 81 details the prohibition of agreements to restrict competition, and Article 82 is about prohibition of abuse of a dominant position. Article 81 TEC provides as follows:

(1) The following shall be prohibited as incompatible with the common market: all agreements between undertakings, decisions by associations of undertakings and concerted practices which may affect trade between Member States and which have as their object or effect the prevention, restriction or distortion of competition within the common market, and in particular those which:

- directly or indirectly fix purchase or selling prices or any other trading conditions;
- limit or control production, market, technical development, or investment;
- share markets or sources of supply;
- apply dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantages; and
- make the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts.

(2) Any agreements or decisions prohibited pursuant to this article shall be automatically void.

(3) The provisions of paragraph 1 may, however, be declares inapplicable in the case of:

- Any agreements or category of agreements between undertakings;
- Any decision or category decisions by associations of undertakings; and
- Any concerted practice or category of concerted practices.

which contributes to improving the production or distribution of goods or to promoting technical or economic progress, while allowing consumers a fair share of the resulting benefit, and which does not:

- impose on the undertakings concerned restrictions which are not indispensible to the attainment of these objects; and
- afford such undertakings the possibility of eliminating competition in respect of a substantial part of the production in question.
This Article therefore lays down: a principle of prohibition (Article 81(1)), subject to possible exceptions (Article 81(3)) and rendering automatically void certain agreements and restrictive practices (Article 81(2)) (Blanco, 2007, pp. 119-120).

Article 82 TEC provides as follows.

Any abuse by one or more undertakings of a dominant position within the common market or in a substantial part of it shall be prohibited as incompatible with the common market insofar as it may affect trade between Member States.

Such abuse may, in particular, consist in:

- directly or indirectly imposing unfair purchase or selling prices or other unfair trading conditions;
- limiting production, markets or technical development to the prejudice of consumers;
- applying dissimilar conditions to equivalent transactions with other trading parties, thereby placing them at a competitive disadvantage; and
- making the conclusion of contracts subject to acceptance by the other parties of supplementary obligations which, by their nature or according to commercial usage, have no connection with the subject of such contracts.

Article 82 TEC does not provide a possibility of exemption as Article 81(3) does. The elements that must be established in order for the prohibition of Article 82 to be deemed to apply are:

- the existence of one or more undertakings;
- the existence of a dominant position within the Common Market or a substantial part of it;
- an abuse of the dominant position; and
- an effect on trade between Member States (Stamatiou and Panayiotis, 2009).

The ruling prohibits an enterprise or enterprises to abuse its or their dominant position within the market of European Community (EC). A dominant position stems from market power held by liner shipping companies on the relevant market. Market power is defined as an ability to raise tariff rate levels and affect the range and quality of shipping services supplied to shippers, the process of innovation or other parameters of competition on the market for a significant period. For liner shipping, market power is presented with high fixed costs, relatively high concentration and tariff rate levels significantly above the marginal cost of production (Pozdnakova, 2008, p. 251). In addition, the market power of a liner shipping company consists in its ability to deviate profitably from marginal cost pricing, so that marginal cost level would be the most appropriate base from which to measure the market power of a given company. Considering the marginal cost and firm’s elasticity of demand are practically impossible to measure directly as well as the positive correlation of market power and market share, it is appropriate to apply market share as a proxy for market power (Hovenkamp, 2005, p. 81). Article 82 EC does not lay down any express criteria to determine that a company’s market power has reached the degree of dominance. The previous cases decided by European Court of Justice indicated that whether a liner carrier or a group of carriers holds a dominant position on the market can be measured by two factors: size of market share and degree of competition faced by the company (Pozdnakova, 2008, pp. 252-53).

Article 81 and 82 TEC, together with Regulation 139/2004 (the EC Merger Regulation), form an integral part of the EC legal system directed at ensuring that competition on the common market is not distorted. The treaty does not lay down any hierarchy between these
rules. Although they are independent provisions, in principle aimed at regulating different situations, they are also complementary, and have the same objective, namely, the maintenance of effective competition on the common market at different levels (Blanco, 2007, p. 412).

3.2 Block exemption for liner shipping conferences

According to Blanco (2007), maritime policy of the EC started to develop in 1974 and was shaped by three main objectives: the promotion of safety at sea, the protection of community fleets against unfair practices by shipowners of third countries and acceptance of the system of shipping conferences in liner trades as a way of organizing the market. As regards Regulation 4056/86, the greatest impetus for reaching an agreement which permitted the application of competition rules to maritime transport came from outside the EU. The most important event for the adoption of provisions implementing ex Articles 85 and 86 of the Treaty of Rome in maritime transport was the approval in Geneva, on April 6, 1974, of the United Nations Convention on a Code of Conduct for Liner Conferences (UN Liner Code). Considering not to infringe upon member states’ right to ratify Liner Code, the EU passed the Council Regulation 4056/86. Except for the influence of Liner Code, the success story of liner conferences also had its basis in economic theory. It was argued and accepted that liner conferences were necessary to secure stability of trade. Due to price competition that would have undermined the stability of maritime trades, liner shipping companies must not be subjected to cartel prohibitions (Munari, 2009).

Council Regulation (EC) No 4056/86 (the so-called “block exemption for liner shipping conferences”) of December 22, 1986, laid down detailed rules for the application of Articles 85 and 86 (now 81 and 82 TEC) of the Treaty of Rome to maritime transport. According to the study of Bredima–Savopoulou and Tzoannos (1990), the purpose of Regulation 4056/86 as set forth in the preambular paragraphs is to steer a middle course between two evils: undue distortion of competition within the common market by a complete laissez faire attitude and excessive regulation of the maritime transport. Some reason and characteristics promoted the adoption of the competition rules. First, it is the misgivings expressed by developing countries in the 1970s about the functioning of the conference system; it is also the result of the Regulation 954/79 concerning ratification or accession by the EC member states to the UN Liner Code. Secondly, the Regulation 4056/86 attempts to steer a middle course between conflicting interests of liner conferences and shippers. The result of this regulation is group exemption to liner conferences couched in the widest possible terms, i.e. a very generous treatment of liner conferences unprecedented in other fields of competition law of the EC. Finally, while its detailed procedural part is a verbatim reproduction of Regulation 1017/68 for applying rules of competition to transport by rail, road and inland waterway, the substantive law of Regulation 4056/86 takes into consideration the particularities of maritime transport.

The Regulation 4056/86 consists of some lengthy preambles and 27 articles. Its major content are as follows:

- scope of application (Article 1);
- technical agreements (Article 2);
- exemptions (Articles 3 and 6);
- condition attaching to exemption (Article 4);
- obligations attaching to exemption – loyalty arrangements (Article 5);
- monitoring of exempted agreements (Article 7);
effects incompatible with Article 86 (now 82) of the treaty (Article 8);
conflicts of international law (Article 9);
procedural rules (Articles 10-27);
liaison with the authorities of the member states (Article 15);
requests for information – investigation (Article 16);
fines – periods penalty payments (Articles 19 and 20); and
entry into force (Article 27) (Bredima-Savopoulou and Tzoannos, op. cit., pp. 180-192).

The Regulation 4056/86 provides, under certain conditions and obligations, for a so-called “block exemption” for agreements, decisions and concerted practices of all or part of the members of one or more liner conferences, as defined in Article 1(3)(b) of the regulation, that have as their objective the fixing of rates and conditions of carriage, and that, in addition, cover one or more of the following forms of cooperation:

- the co-ordination of shipping timetables, sailing dates or dates of calls;
- the determination of the frequency of sailings or calls;
- the co-ordination or allocation of sailings or calls among members of the conference;
- the regulation of the carrying capacity offered by each member; and
- the allocation of cargo or revenue among members (Commission of the EC, 2004).

3.3 European Union decision to repeal the block exemption for liner shipping conferences

As happens for many human matters, the antitrust regime for liner shipping cannot last forever. Two massive changes in international liner shipping altered the conditions for opposing the application of competition rules to liner conferences since the second half of the 1980s. The first is the advent of containerization in liner shipping which brought about a substantial concentration in the market through the mergers and acquisitions process and new forms of cooperation among shipowners (such as the so-called consortia or stabilization agreements). The second is the liberalization in international trade which affected liner shipping companies and their claim to carry a portion of their national trade; more generally, it fostered a historical and political context which was quite different from that in which the UN Liner Code had been devised and adopted (Munari, 2009). These factors jointly promoted the European countries reconsidering whether to eliminate the antitrust exemption for liner conferences.

The EC competition rules are modeled on the presumption that competition provides the best services to the consumer at the most affordable prices. However, the block exemptions for liner conferences from the EC competition rules had been attacked seriously, especially from the shippers’ group (the European Shippers’ Council) (Van der Jagt, 2010). Another decisive factor in the renewed impetus of transport competition policy was the creation in 1987 of the Transport Division of the Directive General for Commission (the so called DG IV or DG Comp) of the EC (Blanco, 2007). In consideration of the liner shipping market has changed since the adoption of Regulation 4056/86 for 18 years, the EC started review process in March 2003 on whether “block exemption” for price fixing and capacity regulation by liner conferences was still justified under Article 81 TEC. The main objective of which was to ascertain whether the policy assumptions supporting the original exemption were still valid. The block exemption was justified on the assumption “that conferences bring
stability, ensuring exporters reliable services which cannot be achieved by less restrictive means.” But, by March 2003, following a number of court cases challenging how the block exemption was to be interpreted, DG Comp’s view was that the liner shipping industry had changed considerably since 1986, and Regulation 4056/86 was overdue for review (Benini and Bermig, 2006).

During the course of its review of the block exemption, DG Comp focused on the four conditions listed in Article 101(3) TFEU that were required for any exemption from competition law:

- **Condition one – efficiency gains**: The exemption must contribute to improving the production or distribution of goods or to promoting technical or economic progress (in this case, stability of freight rates and reliability of service) in ways that flow from (i.e. have a direct causal link to) a conference’s price setting and capacity regulation.

- **Condition two – fair share for consumers**: Any economic benefits achieved by the restriction of competition (i.e. a conference’s rate setting or capacity management activities) must be fairly shared with consumers.

- **Condition three – restrictions are indispensable**: The exempted conduct must be indispensable to achieving the presumed benefits (stable rates and reliable service) flowing from conference price setting or capacity management. That is, no less restrictive way of achieving the presumed benefits is available.

- **Condition four – no elimination of competition**: Conference lines must remain subject to effective competitive constraint (i.e. competition among carriers cannot be eliminated in a substantial part of the market).

After many years’ consultations and discussions with stakeholders and coupled with many studies done by academics and experts, DG Comp’s findings, listed by the relevant Article 101(3) TFEU conditions, were:

- **Condition one**: The carriers had not provided data showing that actual freight rates had been stable, or that rate setting via the conference tariff or conference capacity management efforts had contributed to rate stability or service reliability. DG Comp, after adopting a definition of price stability as “the maintenance of freight rates at a more or less constant level by liner conferences, in accordance with a set structure over a substantial period of time,” asserted that “with or without conferences there is rate volatility” (Benini and Bermig, 2006, p. 45).

- **Condition two**: DG Comp asserted that, even though member lines did not enforce the conference tariff, the existence of published conference rates provided a “benchmark” for member line’s use in setting individually negotiated contact rates. Such “benchmarks” were said to result “in a reduction of shippers’ negotiating power.” In addition, the listing of surcharges and ancillary charges in a conference’s tariff, charges which were subsequently adopted by non-conference lines as well, resulted in there being no price competition between conference members and non-conference members for this part of the trade.

- **Condition three**: DG Comp noted the growth of operational arrangements such as consortia and alliances that did not involve common pricing and pointed out that such consortia and global alliances supported operational efficiencies. In effect, DG Comp suggested that such non-price setting operational agreements combined with the wide use of service contracts were the real sources of any relative service and
rate stability in EU trades, and consequently represented a less anti-competitive way to accomplish the policy goal of the liner block exemption.

- **Condition four**: DG Comp determined that while it appeared that the fourth condition of Article 101(3) TFEU was being fulfilled – that is, competition was not being eliminated from the market – the review’s previous findings (e.g. no clear benefits, restrictions on shipper negotiating power due to tariffs’ benchmark effects and a lack of competition on surcharges) and the increasing links among carriers via operational agreements made it necessary to evaluate the effectiveness of competition on a case-by-case basis rather than endorse a broader block exemption.

While the first finding alone (i.e. no evidence of benefits from allowing carriers collectively to propose common rates or manage capacity) would, in principle, have been enough to support a recommendation to end the exemption, DG Comp strengthened its argument for repeal by claiming shippers were being harmed and the existence of a less anti-competitive alternative to conferences (FMC, 2012, p. 10). The EU then made decision to pass Regulation 1419/2006 in October 2006 to end the block exemption from competition for liner conferences.

Munari (2009) especially pointed out the importance of the study by the Organization for Economic Co-operation and Development (OECD) and its publication of *Competition policy in liner shipping* in 2002, which created a huge influence on EU’s decision on applying competition policy to liner shipping. One piece of the OECD report concluded that:

> It is more difficult to perceive in which manner liner shipping is more “unique” than any other industries, or why it should be treated more favourably or even differently from other transport providers with respect to price-fixing and rate discussion (OECD, 2002).

Regulation 1419/2006 repealed Council Regulation 4056/86 of December 22, 1986, on the application of Articles 81 and 82 TEC to maritime transport containing the liner conference block exemption which allowed shipping lines meeting in liner conferences to fix rates and other conditions of carriage, as the conference system no longer fulfils the criteria of Article 81(3) TEC. The repeal of the block exemption takes effect as of October 18, 2008. Thereafter, liner carriers operating services to and/or from one or more ports in the EU must cease all liner conference activities which are contrary to Article 81 TEC. This is the case regardless of whether other jurisdictions allow, explicitly or tacitly, rate fixing by liner conferences or discussion agreements. Moreover, conference members should ensure that any agreement taken under the conference system complies with Article 81 TEC as of October 18, 2008 (Commission of the EC, 2008).

### 3.4 The possible issues for the European Union action

During the review of Regulation 4056/86, Chuah (2005) pointed out that in the development and provisions of the EC competition law in liner shipping was lack of consistency in approach and would cause some uncertainties on emerging liner practices. For example, inland price fixing by conferences was not permitted. Due to the prevalence of multimodalism in international trade, the effectiveness of EU regulations would be undermined if it held not to apply to multimodal transport services. The US, Canadian and Australian laws allowed conferences to fix prices on inland multimodal transport. Also, the requirement of liner conference being characterized by “uniform or common rates” was outmoded because modern conference practice has moved on to either “independent rate action’ or “service contracts.” In addition, a closer cooperation between the EU and other jurisdictions to discuss how best liner conferences should be regulated was necessary.
Since the EU took radical action to repeal the Regulation 4056/86, the EU Commission also made it clear that, after October 18, 2008, liner conferences operating between trades to and from the member states shall become illegal. Still, people questioned any room would be left for arrangements restricting competition in liner shipping trades. Munari (2009) summarized some important points:

- horizontal agreements among undertakings are always very difficult to justify under the EC competition law; the exception of the block exemption for consortia will fall within the general regime established by Article 81(3) TEC;
- vertical agreements will not raise any concerns as long as they do not touch on issues of dominant position or affect the access to port infrastructures for other shipping lines;
- more uncertain is the evaluation of information exchange. The past cases confirmed that liner shipping companies were not permitted to exchange their pricing or commercial policies and to announce them in public; and
- from the competition law point of view, if non-EU shipping lines operating on European routes claim to be protected by the UN Liner Code, then significant problems may arise.

Unlike the implementation of the US Shipping Act of 1984 which forced the closed conference system should be changed as open conference when engaging in US trades, the European Economic and Social Committee urged for a more complete assessment of the whole matter, instead of only considering the issue from the competition policy perspective.

3.5 Maritime transport services fully apply to European Union competition rules

Following the repeal in 2006 of an antitrust exemption for liner conferences (i.e. agreements between liner shipping companies on common terms and conditions, including fixing prices and other conditions of carriage), the commission adopted the sector-specific maritime guidelines in July 2008 (i.e. Guidelines on the application of Article 81 TEC to maritime transport services (OJ C245/2, 26.9.2008)). The guidelines set out the principles used by the commission when defining markets and assessing cooperation agreements in the maritime transport services sectors, particularly information exchanges between competitors in liner shipping. The initial purpose was to facilitate the transition from a specific to a general competition regime for maritime transport after the nullification of block exemption for liner conferences discussed previously. The commission announced on February 19, 2013, it will not extend or renew its specific guidelines on the application of EU antitrust rules to maritime transport services. The 2008 guidelines expired on September 26, 2013; following their expiry, the commission's general, non-sector specific guidelines will apply to maritime transport services (King and Wood Mallesons, 2013).

A public consultation launched in May 2012 has confirmed to the commission its preliminary view that specific antitrust guidelines in the maritime transport sector are no longer needed. Allowing these specific guidelines for maritime transport services to lapse was in line with the commission's general policy of phasing out sector-specific rules. The commission also noted that the maritime guidelines overlap with other more recent general antitrust guidelines, such as on horizontal cooperation agreements. As a result, from September 26, 2013, maritime transport services will no longer be subject to sector-specific guidelines, but to the general guidelines that are applied to all sectors. These include the following (Bentley et al., 2013):


Although in theory, the sector-specific guidelines (on the application of Article 81 TEC to maritime transport services) have ceased to be applicable after September 23, 2013, it could still be useful to consult them after that date because they provide examples of how the general guidelines apply to certain, specific situations that arise in the maritime shipping sector. The important subjects contained in the guidelines are:

- ascertaining an effect on trade between the member states;
- ascertaining the relevant market;
- calculation of market share;
- horizontal technical agreements;
- horizontal information exchanges in the liner shipping sector; and
- pools in tramp shipping (Stamatiou and Panayiotis, 2009).

3.6 European Union block exemption for shipping consortia agreement
Considering the cooperative mechanism for liner carriers has been evolved from conference system into consortia (or strategic alliances), the “consortia block exemption” from EU competition regulation is still maintained after October 18, 2008, when the block exemption for liner shipping conferences was nullified. Article 81(3) TEC expressly provides for the possibility to exempt not only individual agreements, but also categories of agreements from the prohibition rule of 81(1) TEC. Joint ventures in liner shipping that benefit from the block exemption are liner consortia. Joint ventures of liner shipping companies that comply with the terms and conditions of the consortia block exemption do not need to prove applicability of the four criteria of Article 81(3) TEC on an individual basis, but need only conform to the requirements of the block exemption (Pozdnakova, 2008, p. 199). The “consortia block exemption” was first adopted by the EU Commission in 1995 (the code name is: Commission Regulation 870/95 of April 20, 1995, on the application of Article 85(3) TEC to certain categories of agreements, decisions and concerted practices between liner shipping companies (consortia) pursuant to Council Regulation 479/92). The commission provided the reason why the “Consortia Block Exemption” was adopted due to:

[... ] consortia generally help to improve the productivity and quality of available liner shipping services by reason of the rationalization they bring to the activities of member companies and through the economies of scale they allow in the operation of vessels and utilization of port facilities; they also help to promote technical and economic progress by facilitating and encouraging greater utilization of containers and more efficient use of vessel capacity.

The above rulings were then replaced by Regulation 823/2000, which was subsequently renewed by Regulations 463/2004 and 611/2005. The current law of consortia block exemption is Regulation 906/2009 adopted by the commission on September 28, 2009, which
entered into force on April 26, 2010, and will apply until April 25, 2015, with the possibility of prolongation (Prisker, 2010).

According to the International Transport Forum (2018), the 2009 regulation (i.e. Regulation 906/2009) provides considerably more leeway to consortia than the previous regulation (i.e. Regulation 870/95), in particular on the following elements (Table III):

- **Joint capacity adjustments.** In the revised (2009) regulation, consortia have more freedom to make joint capacity adjustments. In the 1995 regulation, joint capacity planning is only allowed in case of temporary capacity adjustments; in the 2009 regulation, this has changed into “capacity adjustments in response to fluctuations in supply and demand,” which potentially provides for a much broader application. Moreover, the 1995 exemption regulation that prohibits consortia to jointly arrange the non-utilization of existing capacity no longer applies in the 2009 regulation.

- **Price discrimination.** The 1995 regulation stipulates that consortia and consortia members shall not cause detriment to ports, users or carriers by applying different rates and conditions according to the country of origin or destination or port of loading or discharge, unless such rates or conditions can be economically justified. Such a section is absent from the 2009 regulation.

- **Obligation to consult transport users.** The 1995 regulation stipulates that there be real and effective consultations between transport users (or their representative organizations) and the consortia, for the purpose of seeking solutions on all important matters concerning “conditions and quality of scheduled maritime transport services offered by the consortium or its members.” These consultations shall take place whenever requested by one of the parties. The regulation sets out the procedure of these consultations and also gives the commission the right to request consortia members to demonstrate that conditions and obligations in the regulation are still met. Such an obligation is absent from the 2009 regulation.

- **Possibility of withdrawal of the exemption.** The 1995 regulation mentions the possibility of withdrawal of the block exemption in case of ineffective competition and insufficient consultations with transport users. Such a possibility of withdrawal in individual cases of noncompliance is absent from the 2009 regulation.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>1995 Regulation</th>
<th>2009 Regulation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied:</td>
<td>1995-2010</td>
<td>2010-2020</td>
</tr>
<tr>
<td>Maximum market share</td>
<td>30% for consortia in conference. 35% for non-conference consortia</td>
<td>30%</td>
</tr>
<tr>
<td>Joint capacity planning allowed for</td>
<td>“Temporary capacity adjustments”. Joint arrangements of non-utilization of existing capacity are excluded</td>
<td>“Capacity adjustments in response to fluctuations in supply and demand”</td>
</tr>
<tr>
<td>Other conditions for consortia/liners</td>
<td>Not “cause detriment to certain ports, users or carriers by applying to the carriage of the same goods . . . , rates and conditions which differ according to country of origin or destination or port of loading or discharge . . .”</td>
<td>No other conditions</td>
</tr>
<tr>
<td>Obligations for consortia</td>
<td>To conduct real and effective consultations between transport users (or their representatives) and consortia</td>
<td>No explicit obligations</td>
</tr>
</tbody>
</table>

**Source:** ITF, 2018

Table III. EU consortia block exemption regulation: 1995 and 2009 versions
As the Consortia Block Exemption Regulation will expire on April 25, 2020, the EU Commission has launched a consultation seeking to collect views from stakeholders to assist the commission’s assessment of the impact and relevance of the Consortia Block Exemption Regulation and to provide evidence for determining whether it should be left to expire or prolonged, and if so, under which conditions (European Commission, 2018). The report indicated that the International Transport Forum (ITF) was seemingly not to prefer the extension of the EU block exemption for shipping consortia agreement after April 2020. ITF (2018) also pointed out some negative impacts caused by shipping alliances, such as: alliances have allowed carriers to acquire and operate mega-ships to reduce unit costs but fuelled overcapacity; alliances have also made the container transport offer more uniform and limited the possibilities of carriers to differentiate themselves; alliances have contributed to lower service frequencies, fewer direct port-to-port connections, declining schedule reliability and longer waiting times, which resulting in the increased total transport times and delivery uncertainty for various shippers, leading to higher inventory and buffer costs; alliances have proved to be inherently instable; considering that all major carriers are in alliances, changes in one alliance can have an impact on the whole sector; and alliances contribute to concentration of port networks and bigger cargo shifts from one port to another when alliances change port networks; within ports, the buying power of the alliance carriers can create destructive competition between terminal operators and between other port service providers such as towage companies. This can lower the rates of return on investment for the port industry, resulting in the decline of smaller container ports and the disappearance of smaller independent terminal operators, as well as towage companies.

4. The influence on shipping industries

From the regulatory viewpoint, the possible conflict of laws mentioned in Section 3.4 should await the cases occur. For this paper, we study how the shipping markets and carriers will be influenced because the EU banned the conference system. The impact was presented by analyzing the opinions collected from shippers and carriers. The shippers’ opinions on the abolition of shipping conference’s operation by the EU were quoted from the partial results of shippers’ survey conducted by Containerization International (CI) in 2008 (before the conference system was banned) and 2009 (after the conferences were formally lifted). The carriers’ opinions were collected by this study through a questionnaire survey conducted in 2011.

4.1 Shippers’ responses

4.1.1 Shippers’ opinions before liner conference is abolished in European Union trades. In November 2008, CI published its annual shippers’ survey results, where some questions discussing about how shippers’ responses to the shipping conferences to be banned by the EU. The first question handles about what things the substitute association of liner shipping conferences will be allowed to do. Facing the EU action to abolish the liner conference, European Liner Affairs Association (ELAA) was set up in 2003 to discuss with the EU’s Directorate General for Competition (DG Comp) the replacement of the Liner Conference regime in the EU. ELAA was closed since July 1, 2010, and transferred its responsibilities to the World Shipping Council (WSC). As shown in Table IV, the majority of shippers agreed that shipping trade association can be allowed to:

- consolidate each member’ cargo liftings;
- consolidate and publish details of each members’ historic vessel capacity adjustment in each tradelane; and
• consolidate members’ actual freight rates achieved between the major port pairs and then publish freight indices.

Nevertheless, nearly half of shippers (48.5 per cent) still cast some doubts on the publication of freight index by carriers’ association. Regarding the operation of carriers’ trade association, shippers were concerned about the following points:

• there is no problem to consolidate carriers’ operational data such as liftings, vessel capacity or freight index; however, carriers will not allow to conduct group discussion on these information;
• carriers’ trade association should not be permitted anything in addition to what is possible within a free market environment; and
• the collected industrial data should be available to both carriers and shippers.

If possible, the data are better be compiled by independent bodies, such as UNCTAD (United Nations Conference on Trade and Development) or customs, etc.

The issue is whether or not ocean carrier conferences should be banned elsewhere. The answer is positively confirmed. Over two-thirds of bigger shippers (with annual cargo volume over 1,000 TEU) agreed that liner conferences should be banned in the rest of the world (Table V). The small shippers are not so sure about to abolish all liner conferences outside the EU area. Shippers do not like carriers to dominate the market through liner conference system. However, they hope carriers to provide abundant slot for carrying

---

**Question 1:** Ocean carrier conferences are due to be banned in the EU on October 18, 2008. Afterward, do you believe that their trade association should be allowed to:

<table>
<thead>
<tr>
<th>a) Consolidate each members’ cargo liftings so that more accurate cargo flow forecasts can be established?</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>69.7</td>
<td>30.3</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>b) Consolidate and then publish details of all members’ historic vessel capacity adjustments in each tradelane, enabling them to know how full their vessels are likely to be after taking into account public cargo flow forecasts?</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>62.7</td>
<td>38.6</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>c) Consolidate members’ actual freight rates achieved between the major port pairs and then publish indices to show overall port-to-port pricing trends?</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>51.5</td>
<td>48.5</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** Beddow (2008)

---

**Table IV.** Shippers’ opinion on what things the carrier’s association can do after conferences to be banned in 2008

<table>
<thead>
<tr>
<th>Size of shipper (categorized by import/export per year)</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-500 TEU</td>
<td>54.5</td>
<td>45.5</td>
</tr>
<tr>
<td>501-1,000 TEU</td>
<td>42.9</td>
<td>57.1</td>
</tr>
<tr>
<td>1001-5,000 TEU</td>
<td>76.9</td>
<td>23.1</td>
</tr>
<tr>
<td>5001-10,000 TEU</td>
<td>75.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Over 10,000 TEU</td>
<td>88.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Total</td>
<td>74.3</td>
<td>25.7</td>
</tr>
</tbody>
</table>

**Source:** Beddow (2008)

---

**Question 2:** Do you think that ocean carrier conferences should be banned in the rest of the world?

<table>
<thead>
<tr>
<th>Size of shipper (categorized by import/export per year)</th>
<th>Yes (%)</th>
<th>No (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-500 TEU</td>
<td>54.5</td>
<td>45.5</td>
</tr>
<tr>
<td>501-1,000 TEU</td>
<td>42.9</td>
<td>57.1</td>
</tr>
<tr>
<td>1001-5,000 TEU</td>
<td>76.9</td>
<td>23.1</td>
</tr>
<tr>
<td>5001-10,000 TEU</td>
<td>75.0</td>
<td>25.0</td>
</tr>
<tr>
<td>Over 10,000 TEU</td>
<td>88.9</td>
<td>11.1</td>
</tr>
<tr>
<td>Total</td>
<td>74.3</td>
<td>25.7</td>
</tr>
</tbody>
</table>

**Source:** Beddow (2008)
imports/exports. Table VI presents that over 86.3 per cent of shippers concurred with EU to allow the improving operation of shipping consortia after conferences were banned on October 18, 2008. Worried about the shipping consortia to strongly control the market, more than half of shippers (52.1 per cent) were against the maximum trade share for consortia in each tradelane to increase from 35 to 50 per cent.

4.1.2 Shippers’ opinions after liner conference is abolished in European Union trades. Around one year after the EU formally nullified the liner conferences, CI published its shippers’ survey and revealed some investigation on shipping conferences (Dixon, 2009). Two questions dealt with the impact of the ban on liner conferences in EU trades and how this might have changed carrier’s behavior. The enquiry focuses on exploring that opening up market to greater competition might improve customer service functions and pricing responsiveness. Table VII shows that less than 16 per cent of shippers indicated that liner carriers were making “noticeable and significant change” to be more customer

| Question 3: Once conferences are banned in the EU, ocean carriers want the way that they are allowed to cooperate together in consortia to be improved. Should they be allowed to exchange slots with other consortia in the same tradelane, to provide you with a better market coverage? |
|---------|---------|
| Yes     | 86.3 %  |
| No      | 13.7 %  |

| Question 4: Should the maximum trade share of 35% automatically allowed by each consortia in each tradelane be increased to above 50% to enable better economies of scale to be achieved? |
|---------|---------|
| Yes     | 47.9 %  |
| No      | 52.1 %  |

Source: Beddow (2008)

<table>
<thead>
<tr>
<th>Question 1: Liner conferences were banned in the EU in October last year. Since then, have ocean carrier become:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. More customer-focused?</td>
</tr>
<tr>
<td>No change</td>
</tr>
<tr>
<td>Limited change</td>
</tr>
<tr>
<td>Some change</td>
</tr>
<tr>
<td>Noticeable change</td>
</tr>
<tr>
<td>Significant change</td>
</tr>
</tbody>
</table>

| B. More transparent with their pricing? |
| No change                             | 23 % |
| Limited change                        | 40 % |
| Some change                           | 25 % |
| Noticeable change                     | 12 % |
| Significant change                     | 0 %  |

| C. More competitive? |
| No change             | 13 % |
| Limited change        | 19 % |
| Some change           | 34 % |
| Noticeable change     | 28 % |
| Significant change    | 6 %  |

Source: Dixon (2009)
focused. In addition, more than 63 per cent of shippers perceived “limited and no change” on carriers’ practice to be more transparent with their pricing. Regarding the competition between liner carriers after the EU banned the conferences, shippers did perceive more competitive situation occurred in liner market because 68 per cent of them recorded at least some change. There are difficulties to discern shippers remained unimpressed on carriers’ behavioral change and more intensive competition was due to the 2008 financial crisis, resulting in the massive global economic recession in 2009 or the EU abolishing the conference system in October 2008. Despite the ambiguity surrounding the impact of the EU ban on conferences, 74 per cent of shippers felt that they should be abolished in the rest of the world (Table VIII). The results shown in Tables V and VIII indicate that shippers are quite consistent with the opinions to call nullifying liner conferences system all over the world.

4.2 Carriers’ opinions on the conferences issue in Taiwan
To understand how carriers responding to the EU banned the liner conferences system, this study conducted a questionnaire survey in November 2011 in Taiwan after three years the EU invalidated the shipping conferences (Chiu et al., 2012). Due to the limited numbers of international liner carriers operated in Taiwan, totally 31 copies of useable questionnaire were collected. Over two-thirds (67.8 per cent) of the responded companies established more than 20 years, and 38.7 per cent of the respondents have working experience more than ten years in this industry (Table IX). Thus, we believe the respondents are familiar with the

| Question 2: Based on this experience, do you think that liner conferences should be banned in the rest of the world? |
|---|---|
| Yes | 74 % |
| No  | 26 % |

**Source:** Dixon (2009)

<table>
<thead>
<tr>
<th>Profile information</th>
<th>No. of respondents (n = 31) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Job title</strong></td>
<td></td>
</tr>
<tr>
<td>Director and above</td>
<td>8 25.8</td>
</tr>
<tr>
<td>Manager</td>
<td>16 51.6</td>
</tr>
<tr>
<td>Non-managerial or specialist</td>
<td>7 22.6</td>
</tr>
<tr>
<td><strong>Working experience</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;3 years</td>
<td>8 25.8</td>
</tr>
<tr>
<td>3 to approximately 10 years</td>
<td>11 35.5</td>
</tr>
<tr>
<td>&gt;10 years</td>
<td>12 38.7</td>
</tr>
<tr>
<td><strong>Firm’s age</strong></td>
<td></td>
</tr>
<tr>
<td>&lt;10 years</td>
<td>6 19.3</td>
</tr>
<tr>
<td>11 to approximately 20 years</td>
<td>4 12.9</td>
</tr>
<tr>
<td>&gt;21 years</td>
<td>21 67.8</td>
</tr>
</tbody>
</table>

**Source:** Compiled by authors

Table VIII. Shippers’ opinion on liner conferences should be banned in the rest of the world.

Table IX. Profile and respondents and companies.
shipping markets and fully understand the conferences system. In addition, the design of questionnaire is more focused on exploring the influence on market side, instead of legal aspect problems.

As shown in Table X, five aspects are discussed, including influence on:

1. overall liner conference system;
2. European tradelane;
3. Far East/North American tradelane;
4. shipping services; and
5. Taiwan’s ruling system.

Carriers’ opinions on these five aspects will be detailed in the following. First, regarding the influence on liner conference system, over 60 per cent of carriers agreed that two aspects will be greatly impacted, including the global liner conference system and promoting the use of other cooperative agreements (e.g. consortia arrangements). Around 22.6 per cent of them did not think the carrier’s monopoly power in the market will receive more restrictive due to the EU banning the liner conferences.

Second, due to the EU abolishing the conference system, more than two-thirds of carriers agreed that European tradelanes will be influenced on the following points:

- freight rate fluctuation more frequently;
- more competition for container carriers; and
- market share for median to small liner carriers.

Third, discussing the influence on Far East/North American trade routes, over 40 per cent of carriers agreed that the freight rate will fluctuate more frequently and competition between container carriers will be more intensive. Besides, market share for median and small carriers will receive more impact. Fourth, regarding the impact on shipping services, some important points are as follows:

- nearly half of the carriers (48.4 per cent) disagreed that EU to abolish liner conferences would cause negative influence on shipping service reliability; 35.4 per cent of them also disagreed that it would cause positive impact;
- about 38.7 per cent of the carriers agreed that liner service quality and innovation would be positively influenced; nevertheless, still more than one-third (32.3 per cent) of the carriers did not agree that it would cause positive influence; and
- majority of the carriers (61.4 per cent) indicated that removing liner conferences in the EU would cause disadvantages for median and small carriers.

Finally, considering the impact on conference ruling system in Taiwan, majority carriers (70.9 per cent) agreed that government authorities should not intervene in the operation of liner conferences. Interestingly, more than one-third of the carriers disagreed Taiwan government to follow the EU’s action to abolish the liner conferences system; more than one-third of them also disagreed the government to change regulations governing the conferences or consortia arrangements.

Due to lack of strong shippers’ council, it is difficult to sum up opinions from shippers. The shippers’ benefit will be protected by government from proposing a balanced system in the Shipping Act to prevent carriers abusing their market power through cooperative mechanism.
<table>
<thead>
<tr>
<th>Aspects to be influenced</th>
<th>Strongly disagree</th>
<th>Degree of agreement (%)</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A: Influence on liner conference system</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A1. Causing influence on global liner conferences</td>
<td>0</td>
<td>16.0</td>
<td>22.7</td>
</tr>
<tr>
<td>A2. Causing influence only on liner conferences in European tradelanes</td>
<td>6.5</td>
<td>19.3</td>
<td>29</td>
</tr>
<tr>
<td>A3. Causing restriction on a carrier’s monopoly power in market</td>
<td>6.5</td>
<td>22.6</td>
<td>25.8</td>
</tr>
<tr>
<td>A4. Promoting the other cooperative agreements to be used</td>
<td>0</td>
<td>6.5</td>
<td>32.3</td>
</tr>
<tr>
<td>A5. Promoting the other countries considering to abolish liner conferences system</td>
<td>3.2</td>
<td>12.9</td>
<td>38.7</td>
</tr>
<tr>
<td><strong>B: Influence on European tradelanes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1. Causing freight rate fluctuation more frequently in European tradelanes</td>
<td>0</td>
<td>6.5</td>
<td>6.5</td>
</tr>
<tr>
<td>B2. Causing freight rate more stabilized in European tradelanes</td>
<td>0</td>
<td>9.7</td>
<td>19.3</td>
</tr>
<tr>
<td>B3. Causing more competition for container transport in European tradelanes</td>
<td>6.5</td>
<td>9.7</td>
<td>22.5</td>
</tr>
<tr>
<td>B4. Influence on market share for median to small liner carriers in European tradelanes</td>
<td>0</td>
<td>6.5</td>
<td>12.9</td>
</tr>
<tr>
<td><strong>C: Influence on Far East/North American tradelanes</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. Causing freight rate fluctuation more frequently in FE/NA tradelanes</td>
<td>0</td>
<td>25.9</td>
<td>29</td>
</tr>
<tr>
<td>C2. Causing freight rate more stabilized in FE/NA tradelanes</td>
<td>3.2</td>
<td>45.2</td>
<td>19.3</td>
</tr>
<tr>
<td>C3. Causing more competition for container transport in FE/NA tradelanes</td>
<td>9.7</td>
<td>19.3</td>
<td>29</td>
</tr>
<tr>
<td>C4. Influence on market share for median to small liner carriers in FE/NA tradelanes</td>
<td>3.2</td>
<td>25.8</td>
<td>19.3</td>
</tr>
<tr>
<td><strong>D: Influence on shipping services</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1. Causing positive influence on service reliability (e.g. reliable schedule)</td>
<td>9.7</td>
<td>25.7</td>
<td>35.5</td>
</tr>
<tr>
<td>D2. Causing negative influence on service reliability (e.g. reliable schedule)</td>
<td>6.5</td>
<td>41.9</td>
<td>35.5</td>
</tr>
<tr>
<td>D3. Causing positive influence on service quality and innovation</td>
<td>9.7</td>
<td>22.6</td>
<td>29</td>
</tr>
<tr>
<td>D4. Causing negative influence on service quality and innovation</td>
<td>0</td>
<td>29</td>
<td>41.9</td>
</tr>
<tr>
<td>D5. Removing conferences cause disadvantages for median to small shipping carriers</td>
<td>3.2</td>
<td>16</td>
<td>19.4</td>
</tr>
<tr>
<td>D6. Removing conferences help carriers get more flexibility in responding to market changes</td>
<td>3.3</td>
<td>9.8</td>
<td>29</td>
</tr>
<tr>
<td>D7. Causing influence on the volume of international imports and exports</td>
<td>16</td>
<td>29</td>
<td>45.3</td>
</tr>
<tr>
<td><strong>E: Influence on Taiwan’s regulatory system</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Aspects to be influenced</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Normal</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1. Taiwan government should not intervene in the operation of liner conferences</td>
<td>3.2</td>
<td>22.7</td>
<td>3.2</td>
<td>41.9</td>
<td>29</td>
</tr>
<tr>
<td>E2. Taiwan government should follow EU’s action to abolish the liner conferences system</td>
<td>16</td>
<td>19.3</td>
<td>32.3</td>
<td>25.9</td>
<td>6.5</td>
</tr>
<tr>
<td>E3. Taiwan government should amend regulations to limit the operation of liner conferences</td>
<td>12.9</td>
<td>19.3</td>
<td>32.3</td>
<td>29</td>
<td>6.5</td>
</tr>
<tr>
<td>E4. Taiwan government should amend regulations to regulate carrier’s consortium agreements</td>
<td>16</td>
<td>16</td>
<td>29</td>
<td>32.4</td>
<td>6.6</td>
</tr>
</tbody>
</table>

*Source: Chiu et al. (2012)*
4.3 Study on impact conducted by the USA
Considering the importance of the EU to repeal the block exemption for liner shipping conferences, the Federal Maritime Commission (FMC) of the USA also conducted a study to assess what impact the EU repeal might be having on shipping in US liner trades. The major findings for the study are as follows (FMC, 2012, pp. 8-10):

1. Based on an analysis of available information from 2006 through 2010, the study’s primary finding is that no significant changes in rate levels occurred between EU and US liner trades due to the repeal. During the period examined, the repeal of the block exemption also appears not to have put US shippers at a disadvantage to EU shippers in Far East trades.

2. On a pre- and post-repeal comparative basis, differences in the changes in average revenue per 20-ft equivalent unit (TEU) (as a proxy for all-in freight rates) between the eastbound Far East/US trade and the westbound Far East/Europe trade appear to have been trivial. Average revenue per TEU declined by US$150 in the Far East/US trade, and by US$141 in the Far East/EU trade, suggesting that the repeal of the block exemption had little or no effect on average revenue or freight rate levels in the largest US and EU import trades. A comparison between the westbound US/Far East trade and the eastbound Europe/Far East trade shows a similar minor difference in the US and EU export trades. On a pre- and post-repeal comparative basis, average revenue per TEU increased by US$149 in the US/Far East trade, and by US$125 in the Europe/Far East trade.

3. The secondary findings of the study to analyze the two Far East-based trades showed that:
   - The impact of the repeal on average revenue per TEU appears to have been trivial: A result that suggests that the repeal likely did not, independent of the global recession’s impact, produce a relative decline in average rate levels in EU trades as compared with US trades from October 2008 through 2010.
   - There appears to have been an increase in rate volatility in the EU trades: A result that suggests the possibility that the activities of the discussion agreement in the Far East/US trade may have had a dampening effect on rate volatility. However, other factors, such as the prevalence of annual contracts in the Far East/US trade and the difficulty in redeploying very large vessels from the Far East/North Europe trade, may also have contributed to the differences in rate volatility.
   - Following the repeal, there appears to have been a small increase in market concentration: A result that suggests that, in the absence of a forum for carrier discussions and information sharing, market concentration may increase slightly more rapidly.
   - There was a relative decline in market share stability that may be related to rate volatility and market concentration: Market share stability noticeably declined in the Far East/North Europe trade in the post-repeal period. That was also the trade in which relative rate volatility and market concentration appeared to have increased. By contrast, there was increased market share stability in the Far East/US trade.

4.4 Academic research on the impact of governing rules changes on conferences
The USA changed its shipping industry regulation, i.e. passing Ocean Shipping Reform Act (OSRA) in 1998 and came into effect on May 1999 to replace its Shipping Act of 1984. Although the OSRA maintains antitrust immunity for shipping conferences, its creation also
established confidential service contracts between shippers and individual lines. According to Wang’s (2006) study, by examining the volume and freight rates of inbound and outbound trades, he discovered that before the second quarter of 1999 (before OSRA), the transatlantic lane’s market structure was non-competitive, but became competitive from the third quarter of 1999 (following the adoption of OSRA). Applying Adam Smith’s condition of joint product concept, Wang (2014) again examined the eastbound and westbound freight rates on both Transatlantic and Transpacific trade lanes; this study confirmed that the empirical evidences fulfill Smith’s condition of joint product, which, in turn, assures that the US liner market is becoming more competitive after the implementation of OSRA. Su and Wang (2016) conducted a similar research to examine the impact of removing conference system from European liner market. Their analysis results, using available information from 2010 through 2012, reveal that EU’s repeal of conference produced a striking difference in how carriers react to deregulation reform in the two major Europe-based trade lanes. Their empirical results confirmed that the North America/Europe trade lane was competitive after the repeal of conference; however, the competition was not completely free in the Far East/Europe trade lane.

5. The influence on the governing rules on conferences in Taiwan

In Taiwan, the general competition rule relating to the conducts of enterprises is governed by “Fair Trade Act” (referred as FTA) and the competent administration agency is Fair Trade Commission (FTC). Considering the competent administration agency of shipping industry is the Ministry of Transportation and Communication (MOTC) instead of FTC, there is a special design for the MOTC to regulate the competition affairs relating to shipping operators. Article 46 of FTA regulates that:

Where there is any other law governing the conducts of enterprises in respect of competition, such other law shall govern; provided that it does not conflict with the legislative purposes of this Law (i.e., FTA).

As a consequence, the antitrust matters relating to shipping industry are firstly handled by the MOTC and the rule of law is the “Shipping Act.”

The Shipping Act in Taiwan is enacted and initially promulgated on June 3, 1981. Since then, it has been amended six times as of January 22, 2014 (Table XI). Regarding the competition issue on liner conferences, Taiwan’s shipping law does not have detailed regulations, but is in progressive improvement manner. As shown in Table XII, during the initial promulgation on June 3, 1981, there is no formal regulation on liner conferences; in Article 29, only cargo tariffs filing matter is mentioned. The first overall amendment promulgated on February 9, 1995, the Shipping Act formally included rulings on liner conferences and defined it as “International Joint Service Organization (IJSO).” Except for the definition, IJSO is required to file the name, agreement, members of the organization and

| 1. | Promulgated on June 3, 1981 |
| 2. | Amendment to articles promulgated on February 9, 1995 |
| 3. | Amendment to Articles 2, 58, and deletion of Article 6, promulgated on February 3, 1999 |
| 4. | Amendment to Articles 10, 19, 44, 55, 57, 59 and 61, deletion of Article 63 and addition of Articles 33-1, 49-1, 56-1 promulgated on January 30, 2002 |
| 5. | Amendment to whole articles promulgated on January 30, 2013 |
| 6. | Amendment to Article 3 and addition of Articles 27-1, 32-1, 50-1 promulgated on June 19, 2013 |
| 7. | Amendment to Article 60-1 promulgated on January 22, 2014 |

Table XI.
Legislative history of shipping act in Taiwan
Table XII. Evolution of liner conference regulations in Taiwan

<table>
<thead>
<tr>
<th>Time</th>
<th>Shipping Act’s Ruling</th>
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<tr>
<td>June 3, 1981 to February 8, 1995</td>
<td>Article 29: Any vessel carrier engaging in liner service calling ROC ports shall file cargo tariffs with the local shipping administration authority for submitting to the MOTC for filing and inspection. The tariffs of domestic shipping routes should submit to the MOTC for approval. In case of finding the fares, rates or charges mentioned hereinbefore being apparently improper or disadvantageous to the importation and exportation or the development of shipping industry of the ROC, the shipping administration authority may report the situation to the MOTC to order to make corrections and revisions. The authority may also suspend the effect of the whole or part of such tariffs, if it deems necessary. The provisions set forth in the two preceding paragraphs shall also apply to the international joint service organization.</td>
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<td>August 9, 1995 to January 29, 2013</td>
<td>Article 2 (11): (Definition) “International Joint Service Organization” means the organization set up by vessel carriers under an agreement, wherein the member carriers discuss matters relating to the operation in the international routes, such as sea freight rates, passenger ticket fees, volume of carriage and charter space. Article 39: ROC and foreign vessel carriers engaging in ROC commerce while joining an IJSO shall file the name, agreement and the register of members of the organization with the local shipping administration authority for ratification through submission to the MOTC for filing and inspection. The said filing requirement shall also apply to the alteration or dismissal of such organization. If the organization referred to herein before is organized primarily for discussion of freight rates and charges and ticket fares, the tariffs of member carriers may be filed by the organization instead. Whoever fails to act on the provision in the first paragraph herein may be penalized by the suspension of the whole or part of tariffs as the shipping administration authority deems necessary. Article 40: If the agreement of the organization mentioned in the preceding article impedes the ROC order of shipping or economic development, the shipping administration authority may order to make correction within a definite period. Refusal to correct or failure to improve may cause the shipping administration authority to impose on all or part of its member carriers the punishment of prohibition against or restriction of commercial activities in ROC territory.</td>
</tr>
<tr>
<td>30 January 2013 to present</td>
<td>Article 3(10): (Definition) “International Joint Service Organization” means the organization set up permanently or with specific purposes under an agreement achieved on matters relating to the operation in the international routes, negotiations of sea freight rates, passenger ticket fees, volume of carriage and charter space and others relating to operation of routes. Article 3 (11): (Definition) “International shipping protocol” means the convention entered into by the international joint associations to regulate such matters as the relationship between the operators, transport operations, costs, intermodal and cargo picking. Article 34: Any vessel carrier operating in ROC, joining or setting up an IJSO shall file the Articles of Association, proposal for joint operations and relevant documents with the shipping administration authority for ratification through submission to the MOTC for approval on discussion with other authorities. The said filing requirements shall also apply to the alteration or dismissal of such organization. If such international organization is organized primarily on the basis of discussing freight charges and ticket fares, the fares of the member carriers may be filed by those member carriers authorized by the said organization with the shipping administration authority for file and further inspection. Provision of Article 22 applies to such international joint organization. Article 35: Any vessel carrier operating in ROC and entering an international shipping agreement shall file name, content and membership list of such organization. (continued)</td>
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international shipping agreement with the shipping administration authority for submission to the MOTC for approval. The filing requirements stated as above also apply to the alteration of such international shipping agreement. If such international shipping agreement is manipulated primarily on the basis of discussing freight charges and ticket fares, the fare list shall be filed by one of such party, with signatures given on the agreement stated above, with the shipping administration authority for file and further inspection. The fare list stated above shall permit the vessel carrier to make decisions on the freight charges and ticket fares at his own discretion.

Article 49: (Penalties) Any vessel carrier or foreign vessel carrier joining or setting up an IJSO in default in implementation of joint service shall be ordered to improve within a specific period; failure to do so, or if reason for or background of joint service is found to have been extinguished, the MOTC shall coordinate with related authorities to revoke its approval. Failure of performance in the provision set forth in Article 34(2) or 35(2), the shipping administration authority shall, if necessary, suspend the implementation of all or partial fares list.

Article 50: (Penalties) If the operation of the said organization aforementioned or implementation of the said agreement aforementioned impedes the ROC order of shipping or economic development, the shipping administration authority may order correction made within a definite period. Failure to improve may cause the shipping administration authority to report to the MOTC through coordination with related authorities to revoke approval.

Table XII.

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<th>Time</th>
<th>Shipping Act's Ruling</th>
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<td>international shipping agreement with the shipping administration authority for submission to the MOTC for approval. The filing requirements stated as above also apply to the alteration of such international shipping agreement. If such international shipping agreement is manipulated primarily on the basis of discussing freight charges and ticket fares, the fare list shall be filed by one of such party, with signatures given on the agreement stated above, with the shipping administration authority for file and further inspection. The fare list stated above shall permit the vessel carrier to make decisions on the freight charges and ticket fares at his own discretion.</td>
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Since October 2006, the MOTC launched the second overall amendment of Shipping Act (CNA, 2006). Around eight years later, the parliament finally passed the amended law and promulgated on January 30, 2013. The existing law encompasses more governing rules on liner conferences (Table XII). The major points are as follows:

- Definitions. Two things of shipping cooperative mechanism are under-regulated. The first is similar to liner conference and named the “International Joint Service Organization (IJSO).” It is defined as “the organization set up permanently or with specific purposes under an agreement achieved on matters relating to the operation in the international routes, negotiations of sea freight rates, passenger ticket fees, volume of carriage and charter space and others relating to operation of routes.” The second is agreement concluded by members of IJSO and called the “International shipping protocol,” which means “the convention entered into by the international joint associations to regulate such matters as the relationship between the operators, transport operations, costs, intermodal and cargo picking.”

- Registration and approval. According to Article 34, any vessel carrier operating in Taiwan, joining or setting up an IJSO, shall file the Articles of Association, proposal for joint operations and relevant documents with the shipping administration authority for approval. In addition, carriers entering an international shipping agreement are required to file name, content and membership list of such agreement with the shipping administration authorities for approval. The said filing
requirement shall also apply to the alteration or dismissal of such organization or agreement (written in Article 35).

- **Filing tariff.** Both IJSO and international shipping agreement are required to file their tariffs with the maritime authorities for file and further inspection. One special point different with the previous regulation is that “international shipping agreement shall permit the vessel carrier to make decisions on the freight charges and ticket fares at his own discretion.” This ruling is similar to the “independent action” prescribed in the US Shipping Act of 1984.

- **Penalties.** Two kinds of conducts will be punished, including failure of filing tariff and operation with bad practices. In case of filing the tariffs, Article 49 regulates that failure of filing tariffs, the shipping administration authority shall suspend the implementation of all or partial fares list; besides, if the carriers of IJSO violate performing joint services in accordance with the reported agreement, the maritime administration authorities shall coordinate with related authorities to revoke its approval. According to Article 50, if the operation of the IJSO or the implementation of the international shipping agreement impedes the local shipping order or economic development, the shipping administration authority may order correction made within a definite period. Failure to improve may cause the shipping administration authorities to revoke the approval.

Regarding the carriers’ opinions on whether the MOTC needs to change its current administration on liner conferences after the EU lifts the block exemption for shipping conferences. The empirical study results are presented in Table X. One of the mostly strong opinions is that over two-thirds of the respondents (71 per cent) expect the government not to meddle in the shipping market. As to whether government should follow EU’s decision to ban or restrict liner conferences, or tightly control the other cooperative agreements between carriers, the current empirical results do not reveal apparent direction. On questions E2, E3 and E4 (Table X), the respondents indicating opposition and agreement are both quite close to one-third. The possible reasons for this empirical result could be: Taiwan maritime authorities did not launch any investigation on the violation case of IJSO’s operation over the past few decades; nearly no local liner carriers (such as Evergreen or YangMing Line) joined liner conference’s operation; therefore, carriers did not perceive the importance of whether the governing rules needed to be changed or remained the status quo; and comparing to the regulations of the EU or USA on the liner conferences, Taiwan’s regulations are rather simple and loosely control over the liner conferences aforementioned. Therefore, local carriers in Taiwan are more concerned about urging the MOTC not to intervene in the shipping market but are less interested in suggesting government to change regulations on administering the liner conferences.

6. Conclusion and discussion

6.1 Conclusion

The first well-known liner shipping conference was created for the UK/Calcutta trade in 1875. In 1986, EU Council Regulation 4056/86 allowed liner shipping operators to have an exemption from EU competition rules to organize themselves into conferences with the aim of fixing prices and coordination capacity for the transport of containerized cargo. In September 2006, the council of EU decided to abolish that exemption from EU competition rules, with effect from October 18, 2008. From the EU perspective, it finally concluded its review of ending the block exemption for liner conferences and brought the liner industry under the control of normal competition regime. One issue remained undecided is the
handling of the international repercussion of EU relationships with third countries (Munari, 2009) and deserves further study. Instead of totally repealing the liner conferences system, the USA made some improvement to bring a more competitive mechanism into its OSRA of 1998; that changes have seemingly made the US liner market become more competitive after the implementation of OSRA (Wang, 2014). Regarding the EU to repeal the conferences system, empirical studying results did not conclude consistent impact on European liner market in terms of enhancing the competition level (Su and Wang, 2016).

From shippers’ standpoint, the European Shippers’ Council always strongly advocated the abolition of special treatment for liner shipping industry from the EU competition law regime (Van der Jagt, 2010). From the CI’s survey, the majority of shippers support the annihilation of liner conferences system globally. Besides, global shippers also expect two things to be improved following the EU to repeal the liner conference system:

1. carriers should be more customer-focused; and
2. the ocean pricing mechanism should be more transparent (Beddow, 2009).

Shippers seemingly perceived that these two intentions have not yet been realized. Because of the global economic recession in 2009, ocean carriers have been forced to focus on financial survival rather than looking at customer care. Although liner conferences no longer exist in European tradelanes, shipping lines are seemingly still following the prices set by the big carriers such as Maersk and Mediterranean Shipping Company (MSC).

The empirical study conducted by this study about the carriers’ perception on the influence of the EU repealing the block exemption for liner conferences reveals the following important points. First, majority of carriers (over 60 per cent) agreed that obvious impact will be on the global liner conference system and promoting the use of other cooperative agreements (e.g. consortia arrangements). Second, freight rate fluctuation would be more frequently on all tradelanes. Third, the EU to repeal conferences system will possibly:

- help carriers get more flexibility in responding to market changes;
- cause positive influence on service quality and innovation; and
- cause disadvantages for median to small shipping carriers.

Fourth, as to whether Taiwan’s governing rules on liner shipping conferences needed to be changed, responding opinions could not reach a clear direction (i.e. agreement or disagreement). Local carriers in Taiwan seemingly expect the government not to meddle in the shipping market rather than changing the regulation for liner conferences.

Still, it needs further study on some issues, such as:

- the long-term influence of the EU action to abolish the liner conferences in European trades; and
- will the other countries following the EU action to repeal the liner shipping conferences?

Due to the changes of the EU competition ruling on liner conferences, one thing certain is that shipping carriers should fully understand those changes and be vigilant not to violate those newly changed regulations. In addition, “consortia block exemption” is still existed; maritime operators are encouraged to take advantages from the coordination of sailing timetables, the cross-chartering of space or slots on vessels, the pooling of vessels or port installations, the use of joint operations offices, the provision of containers, etc.
6.2 Discussion

6.2.1 The way forward for discussing whether to retain liner shipping conferences. The liner conferences system was originated from European maritime transport markets; it then stretched out across the world. Interestingly, the EU becomes the first party to nullify the liner shipping conferences. The reasons and review processes about why the EU to eradicate

<table>
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<th>EU</th>
<th>USA</th>
<th>Taiwan</th>
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<td>The EU Council Regulation 4056/86 established block exemption to allow carriers to fix prices and regulate capacity jointly in liner conferences. Council Regulation 1419/2006 repealing Council Regulation 4056/1986 on the application of Articles 85 and 86 of the Treaty of Rome to maritime transport and amending Council Regulation 1/2003. The EU Commission also made it clear that, after October 18, 2008, liner conferences operating between trades to and from the member states shall become illegal. Uncertain room left for arrangements restricting competition in liner shipping trades, such as: Horizontal agreements among undertakings are always very difficult to justify under EC competition law; the exception of the block exemption for consortia will fall within the general regime established by Article 81(3) TEC. Vertical agreements will not raise any concerns as long as they do not touch on issues of dominant position or affect the access to port infrastructures for other shipping lines; More uncertain is the evaluation of information exchange. The past cases confirmed that liner shipping companies were not permitted to exchange their pricing or commercial policies and to announce them in public. The EU consortia block exemption regulation (i.e. Regulation 906/2009) would be a good reference if someone would like to propose a regulation to administer the shipping alliances.</td>
<td>The US OSRA of 1998, which took effect on May 1, 1999, laid down detailed rules for the liner conferences. OSRA amended the US Shipping Act of 1984, and continued to allow price fixing and supply regulations agreements, although these have been severely restricted in their content following the major revisions introduced by OSRA in 1999. These regulatory restrictions allow for a greater degree of internal competition, which can be seen through the following provisions: Carriers are allowed to use of independent and confidential service contracts when providing services to their shippers. These contracts introduce a greater level of internal competition among the members of these conference type agreements and allow greater level of independent actions on the part of member lines operating in any joint agreement. Carrier discussion agreements (CDA) are allowed, that basically enable the joint sharing of information among carriers so long as the outcome is not in the form of a price commitment among those sharing the information. Operational efficiency agreements are encouraged, such as multinational alliances and container consortia, both of which are designed to enhance utilization of ships deployed without including any element of price fixing within the operation. Intermodal authority that allows intermodal prices at the level of the agreement has been put in place in the USA since the Shipping Act of 1984.</td>
<td>The Shipping Act of 2013 laid down rules for the liner conferences. No detailed rules were included; it only mentioned the following points: Definitions; Registration and approval procedures; Filling tariffs; Penalty</td>
</tr>
</tbody>
</table>

Sources: Compiled by the author
the competition block exemption for liner conferences would be the valuable information providing for the other countries’ reference. The competition policies relating to shipping is still an important issue. There are serious limitations in the existing system of national filings in terms of understanding and regulating liner shipping alliances; the liner shipping industry has made it difficult for regulators to monitor competitive policies on liner shipping, and therefore, there is a need for a multilateral information-sharing site on vessel-sharing agreements (UNCTAD, 2018). Premti (2016) has undertaken an examination of the state of liner shipping competition policy for UNCTAD and noted the importance of monitoring it, given alliance formation and the instability of alliances at the time.

6.2.2 Implication for Taiwan’s regulatory system for shipping cooperative agreements.
As discussed in Section 5, there are no detailed governing rules on liner conferences or shipping consortia in Taiwan. The empirical studying results also pointed out that local carriers were seemingly less interested in suggesting government to change regulations on administering the freight conferences. Nevertheless, they also did not strongly oppose maritime authorities to follow EU’s action to repeal the liner conferences or to amend the Shipping Act to tightly control the other cooperative agreements between carriers. In the future, Taiwan’s maritime authorities may consider to build up a comprehensive legal system to manage the shipping conferences or alliances. As a consequence, EU-related regulations discussed in Section 3 and those governing rules implemented in the USA would become valuable information to be referred, which were shown in Table XIII.

References
Commission of the EC (2008), “Guidelines on the application of article 81 of the EC treaty to Maritime transport services”.


Further reading


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Influence of transportation infrastructure on the relationship between institutions and economic performance

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Abstract

Purpose – This study aims to analyse the observation that the economics of many countries have boomed after the input of substantial investments into physical and social infrastructures.

Design/methodology/approach – A structural equation model is formulated to examine the effect of transportation infrastructure on the relationship between institutions and gross domestic product per capita (GDPPC). This study further differentiates between developed and developing economies.

Findings – The study identifies the different roles of transportation infrastructure in mediating the relationship between institutions and average income in these two types of economy. Institutions and transportation infrastructure positively influence GDPPC, whereas institutions positively influence transportation infrastructure. In addition, the results found indirect influence of institutions on GDPPC via transportation infrastructure.

Originality/value – This study provides new insights into international business studies based on institutional theory and factor-mobility theory.

Keywords Business location decisions, Institutional theory, Factor-mobility theory

Paper type Research paper

1. Introduction

Within a country or an economy, an institution is established according to a wide range of institutional factors such as capital, information and materials. Movements of these institutional factors are observed across an economy, and the efficient movements of these factors in an economy are often assumed to occur without question. In the literature related to institutions, it is generally accepted that the influence of transport is well established.
However, although the flows of institutional attributes in an economy are multidirectional, the relationship between transport and institutions has yet to be thoroughly examined and verified by empirical research.

It has been shown that an institution has a positive effect on the performance of an economy. The attributes of institutions include much more than just the tangible or physical factors, with the intangible factors also being important. We argue that institutional factors, in general, are relatively immobile factors of economic production, certainly in the short run but likely to be so even in the medium run. In light of these circumstances, an international enterprise will normally wish to find an adequate pool of the required types of institutional attributes already existing in a prospective business location. There may often be a steady domestic movement of institutional factors, but it is likely that the movement will only partially influence the relationship between institutional attributes and economic performance (or average income). The performance of companies in an institution with emergent transportation infrastructure is more diversified than that without such infrastructure, and people will correspondingly suffer economic disparity.

Although some economies have similar institutions, differences in economic performance are observed between these economies. For example, in former British colonies, some have grown more quickly than others (Acemoglu et al., 2001). Scholars have attempted to explain different economic performances in terms of infrastructural development. For instance, Bosworth and Collins (2008) compared the development paths of China and India in terms of their infrastructural development and uncovered the supply-side sources of output change for each of these two economies. Such studies indicate the need to understand any omitted relationship between the institution and economic performance. Many developing economies emphasize investments in transportation infrastructure as a facilitator for economic growth, although developed economies tend to emphasize human resources. Even when the link between the development of infrastructure and economic performance appears relatively obvious, the influence is unevenly distributed across the world and within any particular economy. Furthermore, not all economies rise or fall at the same time. This observation leads to the need to investigate the role of transportation infrastructure in influencing national economic growth.

Our perspective is that “transportation infrastructure” is not part of a country’s or economy’s institutions but does have direct and indirect (mediating) effects on the relationships between institutional attributes and average income. The attribute of “transportation infrastructure” enhances the interactions among institutional attributes and the mobility of those factors or attributes. While we have acknowledged the influence of institutions on economic performance in certain circumstances, we have also recognized the role of factor-mobility in enhancing the relationship between institutional attributes and economic performance. Despite the publication of a number of studies examining the role of transport development and institutional attributes in determining economic performance, most studies in the domain of economic institutions have focused on the institutions with respect to an external economic context while implicitly assuming efficient transport. In this paper, we develop a model and empirically test it by applying both the institutional theory and the factor-mobility theory.

We argue that the development of transportation infrastructure has direct and/or indirect (mediating) effects on the average income per person and on business performance in an economy. Furthermore, we argue that the development of transportation infrastructure has a mediating effect on the relationship between institutions and economic performance. Hence, we shift the argument that economic performance is at least in part a result of
in institutional aspects and transportation infrastructure from an isolated view to a more complementary approach.

The main research objectives of our study are as follows:

- to determine the relationship between institutions and transportation infrastructure; and
- to quantify the role of transportation in mediating the effect of institutions on average income.

If we suppose that “transportation infrastructure” or “physical infrastructure” in general speeds up the evolution to institutional equilibrium, then such transportation infrastructure is not part of the institutional system itself. With poor transportation infrastructure, the institutional system will evolve toward equilibrium more slowly. The attribute of transportation infrastructure reduces the transaction costs of factor-mobility and enhances the institution as a whole.

The present investigation is relevant to the study of international business for two main reasons. First, institutional change generates uncertainties for the international firms that operate in the corresponding institution. The institutional setting affects the selection of the business locations of international firms and their behaviors. Second, the new understanding of the role of transportation in institutions developed in the present study supplements existing international business studies. Location selection is the process that enterprises undergo when exploring market opportunities both across and within nations. The location selection of a firm can be a determinant of its success or failure because the institutions of economies are relatively immobile. Entrepreneurs are able to exploit opportunities that vary from location to location with respect to different institutions, and enterprises, therefore, often make decisions of location selection that are influenced by the distribution and level of institutions and transportation infrastructure. However, the relationship between institutions and transportation infrastructure has not been examined empirically and rigorously.

Transportation infrastructure has been commonly used in some previous studies as a determinant of location selection by enterprises. Chen and Chen (1998) examined the importance of network linkages and location choice to foreign direct investment (FDI). Those authors concluded that network linkages are strong drivers of FDI, as investors can access strategic assets in a foreign country via network connections and can overcome entry barriers and reduce transaction costs in such countries. Bel and Fageda (2008) developed a system of equations to examine the cause-and-effect relationship between the availability of direct non-stop flights and the location choice of large firms’ headquarters across European cities. Those authors found that the presence of direct intercontinental flights is a major determinant in the location choices of large firms’ headquarters, as the availability of direct flights is associated with the communication costs of information exchanges between different cities. Well-established transportation infrastructure not only enables physical accessibility but also lowers the costs of information exchanges and connection networks.

The remainder of this paper is divided into four sections. Section 2 reviews the relevant literature on institution theory and factor-mobility theory. Section 3 contains a discussion of the model used in this study, including a presentation of the methodology and data sources. Section 4 presents the findings. Section 5 discusses the business implications and concludes the paper.

2. Literature review

The foundation of our research framework comprises two elements: institutional theory and factor-mobility theory. Institutional theory is an economic concept that aims to explain the organization of numerous attributes in an economy. Various studies, as discussed below,
have been conducted to analyze economic performance in terms of the possible effect of
different institutions. During the past two decades, institutional theory has emerged as a
powerful explanation to account for the influence of internal institutions on organizational
decision-making and outcomes.

Baker et al. (2005) added a component of comparison into the framework of discovery,
evaluation and exploitation entrepreneurship constructed by Shane and Venkataraman
(2000). Baker et al. (2005) highlighted the important role of institutional structures in
differentiating the opportunities (and costs) of entrepreneurship across nations. Institutions
include the legal system, the financial system and the labor system, and these institutions
influence the value of entrepreneurial opportunities and the potential for business success or
failure. The decisions of entrepreneurs further affect national economic development, as
entrepreneurs contribute to economic activity through the production of goods and services.

Aidis et al. (2008) explored the relationship between institutions and the development of
entrepreneurial activity in Russia. They found that institutional weakness induces lower
levels of entrepreneurial development in transitional economies. However, the business
network of a firm can partly offset the influence of institutions on entrepreneurial activity in
emerging markets.

Many studies have shown that entrepreneurial activity contributes to economic
performance. For example, Bowen and de Clercq (2008) investigated the types of
entrepreneurial activity in the institutional environment contributing to national economic
growth by conducting an empirical study based on Whitley (1999)'s national business system.
Those authors proposed four dimensions of the institutional environment, on the basis of which
they showed that the financial and educational activities of economies positively affect
entrepreneurial allocation and ultimately contribute to the economic growth of economies.

Transaction costs also underpin economic performance. Vanberg (2012) highlighted that
world economic development is driven in large part by technological and political–
institutional factors. Transportation and communication technologies lower transaction
costs, and political–institutional features remove trade barriers and increase the mobility of
capital. Institutions affect national competitiveness indirectly by reducing (or increasing) the
costs of production and directly by providing a more (or less) attractive environment for the
mobility of human and economic resources. Vanberg (2012) examined the role of states in
defining and enforcing institutions (especially with regard to the implications of
globalization for the state's power to tax and regulate) separately to its citizens and non-
citizens.

The creation of wealth is a prerequisite for increasing national economic competitiveness
(Choi, 2012). In particular, entrepreneurs are an important driver of wealth creation through
exploiting profitable opportunities. Therefore, policies addressing economic prosperity
should be formulated based on whether they are likely to enhance entrepreneurship. Choi
(2012) evaluated various schemes and policies directed at cultivating industries for
enhancing national competitiveness and also argued that freedom and protection are
essential for the development of entrepreneurship.

North (1994) argued that institutions constitute formal and informal rules that shape the
economic environment. Institutions are the rules of the game, while entrepreneurs are the
players. Institutions and entrepreneurs interact in such a way as to shape economic changes
and development. However, particular formal rules of developed economies adopted by
developing economies have not enhanced the economic growth of those developing
economies, whereas informal rules/cultures and adaptive entrepreneurs are keys for long-
term growth in such economies. Whitley (1999) proposed four major groups of institutional
factors related to the economic behavior of organizations.
Acemoglu et al. (2005) discussed the role of institutions in promoting economic performance. A broad base of literature provides theoretical support for the role of infrastructural investment in enhancing economic competitiveness. For example, because of its weak and deteriorating infrastructure, India places emphasis on the service economy, while China’s excellent infrastructure has led that nation to excel in manufacturing. In contrast, Japan’s world-leading infrastructure does not appear to have enabled sustained economic growth to occur.

In transport-restricted institutions, firms cannot acquire all the benefits of their own operation in business because some of these institutional attributes accrue to other firms or sectors. Transportation infrastructure allows institutional attributes to spread and diffuse freely from one place to another. Transportation infrastructure also encourages groups of institutions to engage in rent-seeking behavior at different locations within an economy. Therefore, investment in transportation infrastructure generates a better allocation of institutional attributes and an increase in the returns of economic production for economies that make such investment and benefits firms that conduct business in the institutions of economies.

Factor-mobility theory accounts for the flows of production factors in a network consisting of materials, people and information. The coordination and integration of these flows within an economy and between different economies are critical to achieving effective economic production. We argue that because the inter-related nature of many attributes is involved, efficient allocations exist. Therefore, we extend institution theory and incorporate factor-mobility theory to provide mediating effects on the relationship between institutional attributes and economic performance (Figure 1). In addition, it is a tenet of factor-mobility theory that an efficient allocation of institutional attributes in an economy must be developed and maintained. As a result, achieving better economic performance requires the proper transfer of institutional attributes throughout an economy. This important notion forms the basis of our research context, from which we develop a model demonstrating the pathways in which the mobility of production factors is applied in mediating the relationship between institutions and economic performance.

The literature on location selection indicates that the methods for selecting business locations can be categorized into qualitative and quantitative approaches. Papadopoulos (1988) reviewed different statistical approaches (e.g. market segmentation and market estimation) and found that most small- and medium-sized enterprises (SMEs) and even large multinational corporations (MNCs) do not select location using a rational screening process. SMEs consider that statistical analyses for the purpose of screening are too complicated to carry out, while MNCs do not consider screening processes to be cost effective. Papadopoulos (1988) suggested that information published by international organizations can be used to allow comparability for inter-country data and that various methods may be combined to provide cross-validity.
We argue that the institutions of economies (or of countries) in the long run are immobilized or stagnant (in the absence of transportation infrastructure). Entrepreneurs exploit opportunities in a way that is strongly influenced by the different institutional environments that exist in different economies. Cantwell et al. (2010) examined the co-evolution of enterprises responding to the institutional environment. They found that the various institutions of different economies are treated as attractors to those economies and as exogenous advantages. Enterprises cope with these different institutional environments with different forms of engagement, such as avoidance, adaptation or co-evolution, and make decisions through the process of location selection.

Baker et al. (2005) concluded that institutional differences influence the characteristics and level of economic development of a nation as well as the opportunities for individuals. Baker et al. cited Silicon Valley as an example of regional agglomerations that provide easy access to specialized resources through a nation’s institutional supports.

Based on the above literature, we argue that institutional factors retain their influence through economic systems because once these factors have been adopted in an economy, they evolve continuously. However, internal forces, no matter how strong they are, will have no effect on the development of an economy without first affecting some factors within the economy. We argue that transportation infrastructure will enhance the mobility of factors of production and further argue that infrastructural investment mediates the relationship between economic performance and institutional factors. Our theoretical framework is grounded in the proposition that institutional factors affect economic performance after being mediated by infrastructural investment.

3. Research model and hypotheses
3.1 Development of hypotheses
We assume that the economic system is efficient, which means that the performance of certain economies is maximized. Figure 1 portrays our conception of the institutions, factor-mobility and economic performance. We examine both the direct effect of institutions on economic performance and the mediating effect of transportation infrastructure on the relationship between institutions and economic performance. Based on our theoretical proposition that transportation infrastructure mediates the effect of institutions on economic performance, we construct a research model and propose four hypotheses (Figure 2) as discussed below.

3.2 Institutional factors
Institutions are normally defined as the “rules of the game” and include governing structures, laws, rules and norms (North, 1994). We view an institution as a fundamental and essential interaction for a company to engage in and to take advantage of the benefits created by the institutional setting. Nelson (2008) used a broader definition that extends to
the technological advance of an innovation system. Technology is broadly divided into two
groups: physical technology, such as the road network, port infrastructure and other
hardware for enhancing communication; and social technology, such as labor training/
upskilling and collaboration in research and development. Nelson (2008) argued that
physical technology is easier to build but that social technology is harder to borrow.

In the present study, we concur with Nelson’s (2008) view that institutions not only are
limited to laws and governing structures but also include education and training. Nelson
and Nelson (2002) pointed out the important role of institutional structures in supporting
and molding efforts to advance technology. Those authors suggested a broader definition of
the concept of “institution” such that an institution not only is limited to a set of factors that
mold and define human interactions but also includes a process of technological advance
that should be incorporated into an analysis of institutions. Those authors also viewed
“physical technology” as the hardware, including transportation infrastructure, that can be
used for opening up the possibilities of a larger market, whereas “social technology” refers
to the education and collaboration that enable these physical technologies to be
implemented. The innovation system of Nelson and Nelson (2002) explains the
interdependencies between the evolutions of physical and social technologies, which play
the leading role in the process of economic growth.

The importance of technological advance has often been overlooked as a key driving
force behind economic growth. Nelson (2008) pointed out that the role of institutions and of
institutional change in economic growth can be understood only when they are linked to
technological change. Nelson argued that a nation’s ability to design and control institutions
is limited essentially to designing new physical technologies, which would explain why
economic growth is significantly weaker with respect to social technologies compared with
physical technologies.

Therefore, in our study, institutions are denoted by three latent variables, namely:
(1) the training and education system (with the variable “talent” as proxy);
(2) the legal and customs system (with the variable “customs” as proxy); and
(3) the fiscal and financial system (with the variable “finance” as proxy).

Our hypotheses for the influence of institutional factors are as follows:

H1a. There is a positive relationship between talent and the level of institution.
H1b. There is a positive relationship between customs and the level of institution.
H1c. There is a positive relationship between finance and the level of institution.

3.3 Infrastructure factors
Given the importance of transportation infrastructure in an economy, governments are
motivated to invest in such infrastructure. We selected three indicators as components of
the latent variable of “transportation infrastructure.” The indicators, which represent the
communication and connectivity between places are road transport infrastructure, port
infrastructure and air transport infrastructure. Other factors, for example, railway
transportation infrastructure, are excluded, as they are not so common worldwide and/or
suffer from missing data. Our hypotheses regarding transportation infrastructure are:

H2a. There is a positive relationship between the quality of roads and the level of
transportation infrastructure investment.
3.4 Economic performance

Business investment adds to the wealth creation and economic development of an economy. Such investment can be better cultivated in a stable environment through the establishment and enforcement of institutions. Under a fairly narrow definition, institutions exist in the form of regulations, laws, rules, values and culture, amongst others. Such institutions can be represented in various forms; for example, an institution could be government policies that represent or instill the direction of economic development. In a broader definition, institutions include technological advances as forms of system innovation, for example, social technologies.

Institutions may increase/decrease the transaction costs that hinder/favor business development. In other words, favoritism can be interpreted as lowering the threshold for such business development and increasing profitability, whereas penalties can be interpreted as setting a higher threshold for the business and protecting the existing industrial operators. From a microeconomic point of view, institutions may create opportunities for business investment, for example, taxation exemptions or talent training to favor the development of a specific industry. Institutions may also provide constraints on individual businesses or on business development, for example, strict requirements on providing services or a lack of resource restricting training in a specific industry. From a macroeconomic perspective, institutions protect and encourage business investment for creating national wealth. It is hypothesized that well-developed institutions provide fundamental support for economic development. We presume that the separation of developing and developed economies will show comparatively comprehensive and healthy institutions in the latter type of economy.

Institution theory suggests that the profit levels of individual businesses will be affected by institutions. The definition of the economic performance of an average business's profit varies among scholars. Early studies used gross domestic product per capita (GDPPC) as a measure of the average income per person in an economy or as a proxy for the average income of enterprises. GDPPC is the production value of the economy allocated to every individual and can, therefore, be seen as the assessment of the average individual wealth of the inhabitants of an economy. An obvious advantage of using GDPPC is that the values of GDPPC are widely and accurately reported by economies. Therefore, we selected GDPPC as a proxy indicator of economic performance in this study.

We, therefore, propose our third hypothesis:

\[ H3. \] Institutions are positively associated with economic performance.

3.5 Mediation

The mediating effect denotes how a variable affects or changes the relationships that exist between other variables. We argue that transportation infrastructure enhances the mobility of resources so that such resources can be reallocated to higher-productivity activities and locations. There exists a partial mediation process such that institutional attributes have both direct and indirect effects on economic performance. Transportation infrastructure
partially mediates the cause-and-outcome effect of institutional attributes on economic performance. In other words, in the absence of transportation infrastructure, the economic outcome is still generated by institutional attributes. In the modelling, a prior requirement of the mediating effect is the statistically significant relationships between individual variables. In the present case, the mediating effect of transportation infrastructure may exist if the relationships between transportation infrastructure and institutions and between transportation infrastructure and economic development are statistically significant. By using structural equation modelling (SEM), we then decompose the direct and indirect effects of institutional attributes on economic performance, with the indirect effects being interpreted as the mediating effects of transportation infrastructure.

From an organizational learning perspective, the economy has been described as a race, and the developed economy that learns how to race best dominates the global competition (Acemoglu et al., 2005). This presumes that the objective of infrastructure is the acquisition of a competing economy’s specific attributes rather than access to it. Such acquisition of institutional attributes is often transparent and is interpreted as being competitive, rather than collaborative, in nature.

Transportation infrastructure is a means of providing a link from one place to another, and it facilitates the implementation and enforcement of institutions. Various aspects of the planning and operations of transportation infrastructure are derived from different institutions. Transportation infrastructure involves huge investment cost, which is enduring and irreversible. Such infrastructure also involves diplomacy and relationships with other economies, for example, port alliances on handling environmental protection issues.

A government influences the planning and operations of transportation infrastructure through national policy, which originally derives from different institutions. Because transportation infrastructure provides links between locations both within and between nations, national governance is important. Such governance might include, for example, a seaport authority with a free-port policy by exempting the taxation of imported goods or a closed-port policy by restricting the import and export of goods. Another example might be air transportation infrastructure enabling people to travel freely from one economy/nation to another, which may involve tourism policy.

Well-developed transportation infrastructure facilitates communications and connectivity, locally and globally, by lowering transaction (transport) costs and encouraging collaboration and interactions between people and goods. Accessibility furthers the development of both trading and tourism, thereby bringing economic benefits to the economy and further stimulating economic growth. We, thus, propose:

**H4a.** Infrastructure is related positively to economic performance.

An institution provides an external environment for business investment, wealth creation and, ultimately, economic growth. An institution needs the support of transportation infrastructure in providing a linkage from one place to another and by doing so to enable the physical movements of goods and people (trade and tourism). Trade and tourism, in turn, foster economic growth. In other words, transportation infrastructure acts as a catalyst or mediator on the linkage between institutions and economic performance.

In short, transportation infrastructure fosters economic development by supporting institutional enforcement. It is considered that well-developed transportation infrastructure augments the relationship between institutions and economic development:

**H4b.** Transportation infrastructure enhances the influence of institutions on economic performance (positive indirect effect).
4. Data and analysis

4.1 Data collection

Based on the above four hypotheses, we develop a conceptual framework and further identify 24 measurement indicators, which are presented in an SEM. The SEM consists of two components: a measurement model and a structural model. The measurement model includes the components of institutions (law, finance and education) and the items of the corresponding components (indicators). The structural model indicates the directions and strengths of the relationships between the variables.

The extensive academic literature available on the subject of institutions and economic performance has used surveys conducted by various authorities. An established method of gathering research data is the analysis of existing databases and data obtained from previous studies. Such data sets are well defined and accessible for the purposes of the present study, and the measurement indicators contained in them adequately cover all the relevant factors of institutions and infrastructure.

We searched existing data sets from reliable sources and identified the database of Global Competitiveness Index (GCI) as suitable for the present study. The GCI database comprises a survey of closed questions. The questionnaire uses a seven-point Likert scale for responses with answer choices ranged typically from (1) the worst to (7) the best. The data have been collected by the World Economic Forum (WEF). Their annual Executive Opinion Survey captures the opinions of about 14,000 business leaders in more than 140 economies in the first half of the year before publishing (e.g. January to June 2011 for the 2011-2012 report). The survey has achieved around about a 90 per cent response rate in recent years; for example, in the 2014-2015 report, more than 14,000 surveys were sent out, and over 13,200 were returned. To increase the response rate, the survey is translated into more than 40 languages, and it is able to be distributed and completed through the internet.

The questions contained in the survey require simple responses easily made with a sound knowledge of the attributes. The annual survey is conducted through WEF’s network of 160 partner institutes worldwide with the assistance of survey consultancies. After collecting the data, WEF edits the data carefully by excluding problematic responses, such as question completion rates of < 50 per cent. After a multivariate test is conducted using the Mahalanobis distance method, a univariate outlier test is applied at the economy level for each question of each survey. Every individual response carries the same weighting.

Although the survey covers more than 140 economies (about 95 per cent of worldwide GDP) and a wide range of indicators, there are some issues with data coverage and completeness. We checked and removed economies in cases where there were too many missing or incomplete values. This deletion criterion resulted in a data set of 125 economies for further analysis.

We also reviewed the definition of “institution” in the literature of institutional theory and selected various indicators out of a total of 114 identified. We verified whether the selected indicators matched with our methodological design by using factor analysis in SPSS version 24. The objective of principal factor analysis (PFA) is to verify the foreground of the factorial structure. The PFA conducted showed that the measurement of institutions consists of 3 latent variables with 14 indicators and that the measurement of transportation infrastructure consists of 3 indicators.

Multi-group analysis was used to study the potentially different mediating effects of transportation infrastructure on the relationship between institutions and economic performance among developing economies and developed economies. Economies were divided into two data groups (developed economies and developing economies) using the k-means clustering method with respect to the values of GDPPC.
4.2 Initial analysis using SPSS

Although due care was taken while developing all of the measurement indicators, post hoc statistical analyses were conducted on the selected data for the purpose of validation. Specifically, PFA techniques were used to validate all the constructs under investigation. PFA is well established in the SEM literature for the validation of latent constructs (Anderson and Gerbing, 1988). The analyses were performed using SPSS version 24.

Several tests were conducted to evaluate measurement validity. First, internal consistency and convergent validity were assessed. Factor loadings, construct reliabilities, average variance extracted and Cronbach’s alpha of the selected 17 indicators are reported in Table I. The factor loading of each item ranges from 0.62 to 0.96, and all loadings are statistically significant ($p < 0.000$). The values of construct reliability and Cronbach’s alpha exceed 0.4, and the average variance extracted exceeds 0.5, all of which are acceptable (Fornell and Larcker, 1981).

The PFA results (Table I) highlight satisfactory construct reliability and convergent validity for all the constructs under investigation. In summary, all the computed construct reliabilities are above the minimum threshold of 0.70 (Hair et al., 1995), and all indicators load significantly onto the relevant constructs as hypothesized at $p < 0.05$ (Byrne, 1994). The reliability of the data set is, therefore, acceptable.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Factor loading</th>
<th>Cronbach’s alpha</th>
<th>Construct reliability</th>
<th>Average variance extracted (AVE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Institution – Education and training system</strong> (five indicators)</td>
<td></td>
<td>0.93</td>
<td>0.94</td>
<td>0.75</td>
</tr>
<tr>
<td>University-industry collaboration in R&amp;D</td>
<td>0.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Availability of scientists and engineers</td>
<td>0.94</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local availability of specialized research and training services</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of primary schools</td>
<td>0.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of management schools</td>
<td>0.77</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Institution – Legal and Customs System</strong> (three indicators)</td>
<td></td>
<td>0.95</td>
<td>0.82</td>
<td>0.61</td>
</tr>
<tr>
<td>Efficiency of legal framework in settling disputes</td>
<td>0.85</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency of legal framework in challenging regulations</td>
<td>0.83</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transparency of government policy-making</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Institution – Financial and Fiscal System</strong> (six indicators)</td>
<td></td>
<td>0.95</td>
<td>0.87</td>
<td>0.57</td>
</tr>
<tr>
<td>Availability of financial services</td>
<td>0.92</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Affordability of financial services</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of access to loans</td>
<td>0.72</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulation of securities exchanges</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strength of auditing and reporting standards</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prevalence of foreign ownership</td>
<td>0.62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transportation Infrastructure</strong> (three indicators)</td>
<td></td>
<td>0.93</td>
<td>0.93</td>
<td>0.81</td>
</tr>
<tr>
<td>Quality of roads</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of port infrastructure</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of air transportation infrastructure</td>
<td>0.90</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table I. Construct reliability and validity analysis (principal factor analysis using SPSS)
The results of a Kolmogorov–Smirnov test (not reported here) show that most of the indicators are not normally distributed \( p > 0.05 \). Therefore, we used the “bootstrapping with bias corrected” method for correcting/offsetting error or bias in the estimation of SEM. As bootstrapping is used, the raw data are needed for the analysis.

4.3 Structural equation modelling using AMOS

After satisfactory reliability and validity had been established for the constructs, we conducted structural analysis (Anderson and Gerbing, 1988) to test all the hypothesized causal relationships. Specifically, in view of the large number of indicators involved, path analysis was used to perform the analysis (Banerjee et al., 2003). Path analysis is performed by computing the composite scores for all the constructs and using the composite reliabilities to fix the error variances of these constructs (Ganesan, 1994, for details). All the estimated path coefficients and relevant fit statistics derived from the path analysis are shown in Figure 3 and reported in Table II.

The proposed hypotheses were built in SEM form and tested in AMOS. Various model-fit indexes derived from the analysis are given in the lower part of Table II. Most of the model-fit-index-derived \( \chi^2 \) statistics are statistically significant at \( p < 0.05 \), which indicates an inadequate fit of the measurement models (Hair et al., 1995). However, given that the \( \chi^2 \) statistic is highly sensitive to sample size (Bagozzi and Foxall, 1996; Byrne, 1994; Doney and Cannon, 1997), other more powerful fit indexes such as the comparative fit index (CFI), normed fit index (NFI), goodness-of-fit index (GFI) and root mean square error of approximation (RMSEA) were also computed. The values of these indexes all meet the threshold requirements (CFI and NFI > 0.90; GFI > 0.90; RMSEA < 0.1) as suggested by psychometric researchers (Browne and Cudeck, 1993; Hair et al., 1995). To further assess the discriminant validity of the constructs, we follow Fornell and Larcker’s (1981) suggested guideline by examining whether the correlation estimate between any pair of constructs is significantly different from 1.0. The application of this guideline did not detect any

![Figure 3. Structural equation modelling](image)

**Notes:** Summary of fit indices: \( \chi^2 \) proposed model = 1048.109; \( df = 210 \); CFI = 0.956; NFI = 0.945; GFI = 0.893; RMSEA = 0.058
anomalies. Overall, the CFA results demonstrate satisfactory reliability and validity for all the constructs under investigation.

Model fit can be evaluated by using the \( \chi^2 \) goodness-of-fit statistic and/or other absolute- or relative-fit indices (Hu and Bentler, 1999). The results indicate that the Chi-square statistic (\( \chi^2 \)) is 1,048.109 (\( p = 0.000 \)), with 210 degrees of freedom (df). The value of \( \chi^2/df \) is 4.991, which is lower than the accepted threshold of 5. Kelloway (1998) suggested that cutoffs for \( \chi^2/df \) should range from <5 to <2. Overall, the findings provide evidence for a satisfactory fit of the proposed model.

As recommended by Hu and Bentler (1999), we use a two-index strategy, namely, the MLE-based Tucker–Lewis Index (TLI) and the CFI, as well as the RMSEA. In our study, TLI is 0.942, CFI is 0.956 and RMSEA is 0.058. Both CFI and TLI have values of >0.9 and RMSEA is less than 0.08. Other fit indexes, including the incremental fit index (0.95), also indicate that a good fit exists between the model and the data (Hulland, 1996). Concerning hypothesis testing, standardized path estimates derived from the path analysis provide support for all the proposed hypotheses (H1 to H4) at \( p < 0.05 \).

Finally, we tested discriminant validity using the approach suggested by Fornell and Larcker (1981). The square root of the average variance extracted correlated to each construct is higher than the correlation between each pair of latent variables (Table III). Therefore, our measures exhibit the desired discriminant validity. Overall, the measurement model displays satisfactory properties.

The SEM results are summarized in Table IV and Figure 3.

<table>
<thead>
<tr>
<th>Table II. Model fit using AMOS (all economies)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model Fit Target value</td>
</tr>
<tr>
<td>( \chi^2 )</td>
</tr>
<tr>
<td>DF</td>
</tr>
<tr>
<td>( \chi^2/df )</td>
</tr>
<tr>
<td>GFI</td>
</tr>
<tr>
<td>AGFI</td>
</tr>
<tr>
<td>RMR</td>
</tr>
<tr>
<td>SRMR (only ava if plug-in)</td>
</tr>
<tr>
<td>RMSEA</td>
</tr>
<tr>
<td>NFI</td>
</tr>
<tr>
<td>NNFI (TLI)</td>
</tr>
<tr>
<td>CFI</td>
</tr>
<tr>
<td>RFI</td>
</tr>
<tr>
<td>IFI</td>
</tr>
<tr>
<td>PNFI</td>
</tr>
<tr>
<td>PGFI</td>
</tr>
<tr>
<td>CN (HOELTER 0.05)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table III. Results of discriminant validity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variables</td>
</tr>
<tr>
<td>1. Legal and customs system</td>
</tr>
<tr>
<td>2. Education and training system</td>
</tr>
<tr>
<td>3. Transportation infrastructure</td>
</tr>
<tr>
<td>4. Financial and fiscal system</td>
</tr>
</tbody>
</table>

| Note: The square root of AVE is on the diagonal |
### Table IV. Structural equation modeling standardized estimates

<table>
<thead>
<tr>
<th>Construct/Indicator</th>
<th>All economies</th>
<th>Developed economies</th>
<th>Developing economies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Standardized estimates</td>
<td>Standardized estimates</td>
<td>Standardized estimates</td>
</tr>
<tr>
<td></td>
<td>(p-value)</td>
<td>(p-value)</td>
<td>(p-value)</td>
</tr>
<tr>
<td>Institutions → GDPPC</td>
<td>0.382 (0.001)**</td>
<td>0.522 (0.001)**</td>
<td>−0.11 (0.518)</td>
</tr>
<tr>
<td>Education and Training System ← Institutions</td>
<td>0.941 (0.001)**</td>
<td>0.867 (0.001)**</td>
<td>0.935 (0.001)**</td>
</tr>
<tr>
<td>University–industry collaboration in R&amp;D</td>
<td>0.925 (0.001)**</td>
<td>0.916 (0.001)**</td>
<td>0.818 (0.001)**</td>
</tr>
<tr>
<td>Local availability of specialized research and training services</td>
<td>0.943 (0.002)**</td>
<td>0.913 (0.001)**</td>
<td>0.832 (0.001)**</td>
</tr>
<tr>
<td>Quality of management schools</td>
<td>0.863 (0.001)**</td>
<td>0.777 (0.001)**</td>
<td>0.805 (0.001)**</td>
</tr>
<tr>
<td>Legal System ← Institutions</td>
<td>0.838 (0.001)**</td>
<td>0.923 (0.001)**</td>
<td>0.77 (0.001)**</td>
</tr>
<tr>
<td>Efficiency of legal framework in settling disputes</td>
<td>0.972 (0.001)**</td>
<td>0.979 (0.001)**</td>
<td>0.951 (0.001)**</td>
</tr>
<tr>
<td>Efficiency of legal framework in challenging regulations</td>
<td>0.98 (0.001)**</td>
<td>0.979 (0.001)**</td>
<td>0.952 (0.001)**</td>
</tr>
<tr>
<td>Transparency of government policymaking</td>
<td>0.877 (0.001)**</td>
<td>0.902 (0.001)**</td>
<td>0.708 (0.001)**</td>
</tr>
<tr>
<td>Financial System ← Institutions</td>
<td>0.948 (0.001)**</td>
<td>0.919 (0.001)**</td>
<td>0.959 (0.001)**</td>
</tr>
<tr>
<td>Prevalence of foreign ownership</td>
<td>0.712 (0.001)**</td>
<td>0.663 (0.001)**</td>
<td>0.666 (0.001)**</td>
</tr>
<tr>
<td>Regulation of securities exchanges</td>
<td>0.912 (0.001)**</td>
<td>0.895 (0.001)**</td>
<td>0.894 (0.001)**</td>
</tr>
<tr>
<td>Strength of auditing and reporting standards</td>
<td>0.927 (0.001)**</td>
<td>0.946 (0.001)**</td>
<td>0.832 (0.002)**</td>
</tr>
<tr>
<td>Affordability of financial services</td>
<td>0.918 (0.001)**</td>
<td>0.89 (0.001)**</td>
<td>0.859 (0.001)**</td>
</tr>
<tr>
<td>Transportation infrastructure ← Institutions</td>
<td>0.928 (0.001)**</td>
<td>0.854 (0.002)**</td>
<td>0.855 (0.001)**</td>
</tr>
<tr>
<td>Transport → GDPPC</td>
<td>0.424 (0.001)**</td>
<td>0.273 (0.011)**</td>
<td>0.527 (0.001)**</td>
</tr>
<tr>
<td>Quality of roads</td>
<td>0.858 (0.002)**</td>
<td>0.801 (0.001)**</td>
<td>0.766 (0.001)**</td>
</tr>
<tr>
<td>Quality of port infrastructure</td>
<td>0.917 (0.001)**</td>
<td>0.91 (0.002)**</td>
<td>0.795 (0.001)**</td>
</tr>
<tr>
<td>Quality of air transportation infrastructure</td>
<td>0.938 (0.001)**</td>
<td>0.92 (0.001)**</td>
<td>0.896 (0.001)**</td>
</tr>
<tr>
<td>Direct Effect (Institutions → GDPPC)</td>
<td>0.382 **</td>
<td>0.522 **</td>
<td>−0.11</td>
</tr>
<tr>
<td>Indirect Effect (Institutions → Transport → GDPPC)</td>
<td>0.393 **</td>
<td>0.233 **</td>
<td>0.450 **</td>
</tr>
</tbody>
</table>

**Notes:** *p < 0.05; **p < 0.01
5. Discussion

5.1 Theoretical contributions

By empirically validating a theoretical model, this study offers three major contributions to the literature on international business studies. First, as a novel contribution, we have investigated the extent to which “infrastructure” mediates the effects of institutions on economic performance. Second, recognizing the inherent multidimensionality of the concept of “institutions,” we have conceptualized the construct at a refined level by discriminating between developed and developing economies. Third, we have extended prior research on institutions and infrastructure investment in both developed and developing economies.

We found significant relationships between 1) transportation infrastructure and institutions and 2) transportation infrastructure and GDPPC, which means that transportation infrastructure acts as a mediator (rather than a moderator) between institutions and economic performance. The empirical tests of the proposed model support its validity for representing institutions. Our findings indicate that an institution can be represented by three attributes, which are represented by 14 factors.

Economic performance and advancement do not consist only of the discrete importance of separate institutional attributes and transportation infrastructure. To advance an economy, an entire institution is radically changed. With the aid of transportation infrastructure, institutional attributes can circulate easily within a developing economy. For developed economies, economic growth has become increasingly dependent on intangible attributes as a source of growth. Economic advancement can scarcely be further achieved through simply shifting attributes but rather by a more intensive use of institutional attributes and greater institutional sophistication.

We divided the data set into developed and developing economies according to GDPPC (a proxy for individual business performance) and used the SEM to determine the heterogeneous effects between these two types of economy. Overall, the SEM estimates of the two groups were similar, meaning that institutional attributes have similar relationships to GDPPC for both groups. Nevertheless, transportation infrastructure shows different patterns for developed and developing economies, while $H3$ is not statistically significant for developing economies (Figure 2). Developed economies, with better transportation infrastructure compared with developing economies, tend to have a better transfer of institutional attributes. This reflects the fact that the development of transportation infrastructure leads to relatively low transport costs. Our empirical evidence shows that the effect of transportation infrastructure is more pronounced in developing economies than in developed economies.

Our findings enrich the theory on national economic competitiveness by confirming that infrastructural investment is a significant factor in the competitiveness of developing economies. However, the effect of infrastructural investment on competitiveness disappears when an economy reaches the state of ‘middle-income trap.’

5.2 Managerial implications

Our findings suggest that business location decisions should rely not only on the institutions of an economy but also on transportation infrastructure. Our study provides empirical evidence for how transportation infrastructure mediates the effect of institutions on economic performance, especially in developed economies; therefore, international corporates should evaluate transportation infrastructure to harness the best from the particular institutions. The underlying concepts of factor-mobility and institution are identified as key challenges for management in attempting to convert the macro business environment into business potential.
We note that transportation infrastructure has different effects for developed and developing economies. For business managers, transportation infrastructure is a critical element for location decisions when they consider developing economies because the institutional attributes of developing economies cannot function efficiently without transportation infrastructure. Rather than simply locating a firm with respect to better institutional settings and advanced transportation infrastructure, it is important to first identify the economic performance (GDPPC) of the economy before formulating an effective strategy. As a result, a small firm operating in developing economies can reap significant competitive advantages through leveraging transportation infrastructure.

In terms of firm location selection, both institutions and transportation infrastructure are important factors, and their combined effects are distinct in developing and developed economies. In developing economies, institutions rely on transportation infrastructure to operate, but effective transportation infrastructure cannot be assumed. In developed economies, transportation infrastructure enhances the effect of institutions, and the effectiveness of transportation infrastructure can be considered after that of institutional attributes. Therefore, transportation infrastructure is critical in the consideration of firm location selection, especially if a developing economy is a candidate location.

6. Conclusions
Our investigation into institutional attributes and transportation infrastructure contributes to the analytical and methodological aspects of research in the field of institutional theory. In the absence of a widely accepted way of measuring institutions, we defined institutions empirically in terms of three attributes, namely:

1. the education and training systems;
2. the legal and customs system; and
3. the fiscal and financial system.

The findings of the study broaden and deepen our understanding of institutional dynamics in both developed and developing economies.

We tested the mediating effect of transportation infrastructure on the relationship between institutions and economic performance. In other words, this study investigated how transportation infrastructure facilitates the effects of institutions on economic performance. When firm location selection is considered, decision-makers and managers need to understand that transportation infrastructure has different roles in developing and developed economies. Our study provides evidence that institutions in developing economies cannot function without transportation infrastructure and that institutions in developed economies are enhanced in the presence of transportation infrastructure.

Future avenues for research could aim to overcome some of the limitations of our study or to extend the investigation into particular sectors or industries. Our investigation focused on the international business environment, and caution should, therefore, be exercised in generalizing the findings to the contexts of particular businesses or types of business activity. Our results may differ from those of previous studies for particular sectors because we used different factors to define institutional attributes and infrastructure. Therefore, future investigations could be made of particular industries affected by different institutional attributes and types of infrastructure.
References


Further reading

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Selection of effective risk mitigation strategies in container shipping operations

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Abstract

Purpose – Container shipping companies face various risks with different consequences that are required to be mitigated. Limited empirical research has been done on identifying and evaluating risk management strategies in shipping operations with different risk consequences. This paper aims to identify the appropriate risk mitigation strategies and evaluate the relative importance of these strategies.

Design/methodology/approach – Literature review and interviews were used to identify and validate the appropriate risk mitigation strategies in container shipping operations. A questionnaire with a Likert five-point scale was then conducted to rank the identified risk mitigation strategies in terms of their overall effectiveness. Top six important strategies were selected to evaluate their relative importance under three risk consequences (i.e. financial, reputation and safety and security incident related loss) through using another questionnaire with paired-comparison. Fuzzy analytic hierarchy process (AHP) was then conducted to analyse the paired-comparison questionnaire.

Findings – After conducting a systematic literature review and interviews, 18 mitigation strategies were identified. The results from the first questionnaire show that among the 18 strategies, the top three are “form alliances with other shipping companies”, “use more advanced infrastructures (hardware and software)” and “choose partners very carefully”. After conducting fuzzy AHP, the results show that shipping companies emphasize more on reducing the risk consequence of financial loss; and “form alliance with other shipping companies” is the most important risk mitigation strategy.

Originality/value – This paper evaluates the risk mitigation strategies against three risk consequences. Managers can benefit from the systematic identification of mitigation strategies, which shipping companies can consider for adoption to reduce the operational risk impact.

Keywords Container shipping, Risk management, Risk mitigation strategies, Fuzzy AHP, Survey

Paper type Research paper
1. Introduction
Risks have always been an important issue in container shipping operations as they may lead to various severe consequences. For example, Chang et al. (2014; 2015; 2016) identified three types of risks in the container shipping industry from a logistics perspective: risks associated with the information flow, physical flow and payment flow. They also identified three types of risk consequences, including financial loss, reputation loss and safety and security incident-related loss. Financial loss is the most common risk consequence, for which a monetary value is typically used to measure its severity. Reputation loss is a type of non-financial loss that harms a firm’s reputation. Safety and security incident-related loss refer to another type of non-financial loss that results in injury/loss of life to the crew and their families. Tummala and Schoenherr (2011) found that risk consequences may include loss of or damage to assets, loss of income, interruption of service levels, cost overruns, schedule delays, poor process performance, liabilities incurred, damage repair costs, injuries or their combinations.

To reduce the negative impact of such risks, identifying appropriate and effective risk mitigation strategies for container shipping companies has attracted much attention from both academia and the shipping industry (Wan et al., 2019). The studies in the field, however, have largely focussed on one or a few risk mitigation strategies responding to only one type of risk consequence. For example, researchers have addressed empty container handling to reduce operational cost (Lu et al., 2010; Song and Dong, 2011, 2012), the topic of fleet deployment (Ng, 2015; Zhao et al., 2016), delays through timetable designs intended to reduce reputation loss (Qi and Song, 2012; Wang and Meng, 2012a, 2012b; Ng, 2015) and implementation of international regulations to reduce safety and security losses (Lun et al., 2008). Few of them holistically discussed risk mitigation strategies in relation to the three risk consequences mentioned above (financial loss, reputation loss and safety and security loss). This study attempts to provide a systematic review of risk mitigation strategies in the container shipping industry and an analysis of the effectiveness of the identified strategies. Notably, some of the shipping risks are closely inter-relative, and thus, the risk mitigation strategies are not designed for only a specific risk. In particular, this paper aims to address the following research questions:

RQ1. What are the potential strategies that can mitigate risk in container shipping operations?
RQ2. What strategy(ies) is (are) the most important to be addressed?

They are important questions because a shipping company has limited resources to manage risks, and it is, therefore, crucial for managers to know the priority of risk mitigation strategies when they have a specific goal to avoid all consequences of risk or some specific types of risk consequence. Different companies may have different goals when managing risks (Chang et al., 2016). For example, smaller companies may place a greater emphasis on mitigating financial loss, whereas larger companies may focus on reputation loss. This study adopts the structure of risk consequence proposed by Chang et al. (2014, 2015, 2016), which presents a relatively comprehensive list of consequences relating to the container shipping environment.

The contributions of the article are twofold: firstly, through comprehensive interviews and a literature review, the strategies for risk mitigation for container shipping operators are identified. This will provide operators with useful information on the available strategies intended to reduce negative impacts from risks. Secondly, the priority of the identified strategies with respect to three risk consequences and their overall priorities are also
determined, respectively. Because of the scarcity of resources, shipping companies have to invest wisely in various risk mitigation strategies. This study will be useful for them to determine the sequence of investment in risk mitigation.

The rest of the paper is organised as follows. A literature review is conducted to identify current risk mitigation strategies in Section 2. The research methods adopted in this study are presented in Section 3, including the literature review, a set of interviews, two questionnaire surveys and the fuzzy analytic hierarchy process (AHP) method. Section 4 focusses on the empirical data analysis on their importance. Discussion and conclusions are drawn in Section 5 based on the results of the study.

2. Identification of risk mitigation strategies from the literature review
Many risk mitigation strategies have been revealed from previous studies. For example, to deal with slight delays, shipping companies could include a time buffer when designing the timetable/schedule to reduce the impact of an unreliable schedule. The benefits of adding a time buffer include: the shipping schedule will be more flexible, thus offering opportunities to reduce the impact of uncertainties and delays at transport nodes (e.g. ports) and during transport (e.g. on the sea); a more robust shipping network; and minimisation of impact of port time uncertainty on operational costs (Notteboom, 2006; Notteboom and Vernimmen, 2009; Chopra and Meindl, 2010; Qi and Song, 2012; Wang and Meng, 2012a, 2012b; Oppen, 2016). Some studies investigated a slow steaming strategy, which is to reduce the sailing speed to an appropriate speed for significant reduction of fuel consumption costs (Notteboom, 2006; Notteboom and Vernimmen, 2009; Cariou, 2011; Ronen, 2011; Qi and Song, 2012; Mander, 2016). Some researchers suggested using more advanced information communication technology (ICT) infrastructure (Stefansson, 2002; Porter, 2008). To improve safety and security, companies can also use some initiatives (e.g. ISPS Code, the Container Security Initiative and the Customs-Trade Partnership Against Terrorism) or technologies (e.g. RFID, the SMART box initiative and container non-intrusive inspection) (Lun et al., 2008; Chang et al., 2014; Nair, 2015) and/or execute regular employee training (Shang and Lu, 2007; Young, 2010; Ganesan, 2010).

In terms of the external risks introduced by their partners (in supply chains), shipping companies can use their influence to reduce the negative impact from partners with the bad performance or to improve the positive impact from partners with good performance (Cruz and Marques, 2012). Shipping companies can also build trust with partners (Kwon and Suh, 2005; Sodhi and Son, 2009) and then further enter into long-term contracts with shippers (Notteboom, 2004), share information with partners without co-management (Harrison and Hoek, 2005; Schmidt, 2009), exchange ideas with partners to resolve conflicts or improve service quality (Harrison and Hoek, 2005; Sodhi and Son, 2009). They can also form alliances with other shipping companies (Lu et al., 2010; Tan and Thai, 2014; Rau and Spinler, 2016) or acquire and merge with other shipping companies (Notteboom, 2004; Lu et al., 2007). Table I summaries the risk mitigation strategies from the existing literature.

3. Research methods
3.1 Identification of risk mitigation strategies
3.1.1 Identification of risk mitigation strategies through literature review. To identify the risk mitigation strategies that can be used by container shipping companies, an extensive literature review was conducted in Section 2, followed by face-to-face interviews to validate the findings of the literature review. Literature reviews are often used to identify risk mitigation strategies in academic studies (Mitchell, 1995; Ellegaard, 2008; Veselko and Bratković, 2009). To inclusively identify the risk mitigation strategies appropriate
<table>
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<tr>
<th>Strategies</th>
<th>Purpose of the strategy</th>
<th>Authors</th>
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<tr>
<td>1. Be flexible when designing the timetable/schedule, e.g. buffer times</td>
<td>To deal with slight delays, shipping companies could include a time buffer when designing the timetable/schedule to reduce the impact of an unreliable schedule. The benefits of adding a time buffer include: the shipping schedule will be more flexible, thus offering opportunities to reduce the impact of uncertainties and delays at transport nodes (e.g. ports) and during transport (e.g. on the sea); a more robust shipping network and minimisation of impact of port time uncertainty on operational costs</td>
<td>Notteboom (2006), Notteboom and Vernimmen (2009), Chopra and Meindl (2010), Qi and Song (2012), Wang and Meng (2012a, 2012b), Oppen (2016)</td>
</tr>
<tr>
<td>2. Implement slow steaming by increasing the number of ships on existing routes</td>
<td>Reducing the sailing speed to an appropriate speed can significantly reduce fuel consumption costs</td>
<td>Notteboom (2006), Notteboom and Vernimmen (2009), Cariou (2011), Ronen (2011), Qi and Song (2012), Mander (2016)</td>
</tr>
<tr>
<td>3. Use more advanced infrastructure (hardware and software)</td>
<td>The potential risks associated with E-commerce have been used in some companies, including container shipping, for some years. It is suggested that using more advanced infrastructures could reduce the impact of such risks. This strategy also covers using an advanced information communication technology (ICT) infrastructure</td>
<td>Porter (2008), Stefansson (2002)</td>
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<tr>
<td>4. Improve safety and security</td>
<td>Companies can use some initiatives (e.g. ISPS Code, the 24-h Advance Manifest Rule, the Container Security Initiative, and the Customs-Trade Partnership Against Terrorism) or technologies (e.g. RFID, the SMART box initiative, and container non-intrusive inspection) to improve the level of security</td>
<td>Lun et al. (2008), Chang et al. (2014), Nair (2015)</td>
</tr>
<tr>
<td>5. Execute regular employee training (e.g. every year or bi-annually)</td>
<td>Employee training is an important strategy to deal with human-caused risks in almost every company. Through a regular employee training programme, companies can significantly reduce human-caused risks in a firm especially when employees face a complex IT system or work in a dangerous environment</td>
<td>Richardson (2000), Elkins et al. (2005), Shang and Lu (2007), Young (2010), Ganesan (2010)</td>
</tr>
<tr>
<td>6. Avoid too many partners</td>
<td>Reduce the number of suppliers if the suppliers are too many. The benefits of using this strategy include reducing the cost of maintaining relationships with too many partners, improving the relationship between fewer and good-performance partners, and reducing the probability of having bad-performance partners</td>
<td>Harland (1996)</td>
</tr>
<tr>
<td>7. Shorten/withdraw contracts with partners who have bad performance</td>
<td>Shipping companies can use their power to reduce the negative impact from partners with bad performance</td>
<td>Geyskens and Steenkamp (2000), Cruz and Marques (2012)</td>
</tr>
<tr>
<td>8. Reward/assist partners who comply with shipping line initiatives</td>
<td>Shipping companies could use their power to increase the positive impact from partners with good performance</td>
<td>Geyskens and Steenkamp (2000), Cruz and Marques (2012)</td>
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(continued)
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<th>Strategies</th>
<th>Purpose of the strategy</th>
<th>Authors</th>
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<tr>
<td>9. Build trust with partners</td>
<td>To avoid the risk of vessel underutilisation, an important strategy is to establish close relationships with major shippers. “Trust” is an important element affecting partner relationships, and trust should be established in a long-term partnership</td>
<td>Kwon and Suh (2005), Sodhi and Son (2009)</td>
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<tr>
<td>10. Enter into long-term contracts with shippers</td>
<td>The benefits of entering into long-term relationships with supply chain partners and building a degree of trust include strengthening the partner relationship between the company and their customers and securing cargo volume for container shipping companies</td>
<td>Notteboom (2004)</td>
</tr>
<tr>
<td>11. Share information with partners without co-management (cooperation level)</td>
<td>Information sharing is the most basic level of partner co-operation in a risk mitigation strategy. Specifically, channel members share partial information without involving explicit cooperative activities. The focus company usually uses this strategy when it is not very familiar with its partners</td>
<td>Harrison and Hoek (2005), Schmidt (2009)</td>
</tr>
<tr>
<td>12. Exchange ideas with partners to resolve conflicts or improve service quality (coordination level)</td>
<td>A more advanced level of information sharing includes not only exchanging data/ideas with partners but also cooperatively resolving problems or conflicts caused by incompatible goals between channel members. The benefit of using this strategy is that it can maintain the efficiency of supply chain systems and reduce conflict through deeper discussion with partners</td>
<td>Elkins et al. (2005), Harrison and Hoek (2005), Sodhi and Son (2009)</td>
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<td>13. Collaborate with partners</td>
<td>Collaboration with partners is the highest level of the “co-operation” relationship. In the maritime environment, a dedicated terminal is an important form of joint venture between container shipping companies and container ports/terminals. Container shipping companies may use joint ventures with port/terminal operators to reduce the impact of port congestion, which is the main source of schedule unreliability</td>
<td>Notteboom (2004, 2006), Harrison and Hoek (2005)</td>
</tr>
<tr>
<td>14. Form alliances with other shipping companies</td>
<td>Strategic alliances can help companies effectively use resources/equipment and share risks. Each shipping company in an alliance group often contributes several ships that co-operate on the same routes, which could lead to sharing of the capital investment and risk for these shipping companies</td>
<td>Notteboom (2004), Lu et al. (2010), Tan and Thai (2014), Rau and Spinler (2016)</td>
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<tr>
<td>15. Acquire and merge with other shipping companies</td>
<td>Acquisition is deemed a quick and effective way to increase profit, expand the business and improve competitive position. A merger is viewed in the same way. This strategy can reduce the risk impact when container shipping companies plan to develop in a new market</td>
<td>Notteboom (2004), Lu et al. (2007)</td>
</tr>
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Source: Authors
for the container shipping, both the literature directly relating to container shipping risk management and the literature in the field of risk management of general supply chain were reviewed as the latter studies may have incorporated strategies that are applicable to container shipping. For example, regular employee training as an important risk mitigation strategy in general supply chain management (Richardson, 2000; Elkins et al., 2005), can also be used in container shipping operations (Young, 2010). Thus, reviewing the literature related to general supply chain management was used to further confirm the applicability of the strategies identified from the literature related to container shipping operations.

3.1.2 Validation of risk mitigation strategies through interviews. After the literature review was completed, to validate the literature review findings and also to explore any additional risk mitigation strategies in container shipping operations, a set of face-to-face interviews were conducted. In the face-to-face interview, the managers were asked to modify the strategies if they felt any strategies described in Table I are inappropriate, to confirm and support the strategies if they thought the strategies are appropriate or to propose other relevant strategies if they felt there are some strategies that have been used in container shipping operations but yet mentioned in Table I.

In total, seven managers from two major world leading container shipping companies participated in the interviews, including two vice-presidents, two senior managers in the IT department and three senior managers in the operations department. Based on the results of the interviews, all mitigation strategies in Table I was confirmed to be appropriate by having the consensus from the interviewees. In addition, three additional strategies were proposed as follows.

As an international business, a shipping company has to implement international regulations to mitigate the negative impact of both security and safety issues in container shipping operations. A senior manager said:

We have already used ISO 27001 to increase information security [...]. We implement the IMGD Code, an international regulation, which can reduce potential risks in shipping operations when transporting dangerous goods.

In the context of the container shipping supply chain, every entity in the channel is important, and a weak or problematic one will cause a negative impact on container shipping performance or its partners’ performance. Choosing appropriate partners is an important issue in shipping operations. A senior manager stated:

Sometimes we need to handle or face the risk related to the shippers who are bankrupt before they make payment. In order to reduce such risk, we have to do some credit search about the shippers or supply chain partners to avoid doing business with the shippers who have bad credit or unstable finances. Sometimes shipping companies will transfer this risk to forwarders [...].

In container shipping operations, cultivating the loyalty of supply chain partners can reduce the uncertainty of transportation demand. One manager stated:

We usually cultivate loyalty with our partners and make a long-term contract with shippers to reduce uncertain transportation demand, and these strategies also help maintain minimal revenue for us.

Based on the above remarks, we formulated four new mitigation strategies as follows. Firstly, two strategies are refined and separated from the original Strategy 4. They are “improve security measures, such as by implementing security rules and regulations like the ISO 27001 and ISPS Code” and “improve safety measures, such as by implementing safety rules and regulations like the IMDG Code and ISM Code”. Secondly, two other strategies are identified based on the interview results: “choose partners very carefully”, and “cultivate the
loyalty of supply chain partners”. Therefore, we summarised the risk mitigation strategies used in container shipping in Table IV*[1], where the new strategies identified from the interviews are in italic (i.e. No. 4, 5, 8, 11).

In Table IV, it is noteworthy that the partners mentioned in Strategy 13 only refer to shippers, while those in Strategy 16 are not shippers. The difference lies in that shipping companies play different roles in the associated supply chains: in a cargo supply chain (Strategy 13), the role of the shipping company is on the supply side, whereas in the service supply chain (Strategy 16), it is on the service demand side, and its supply chain partners are on the service supply side (e.g. terminal operators provide lifting on/off services to shipping companies).

3.2 Measurement of the effectiveness of risk mitigation strategies
After identifying the strategies, we conducted a large scale questionnaire survey, namely, “mitigation-strategy survey”. This survey was conducted using a five-point Likert scale, where 1 meant “very inefficient” and 5 meant “very efficient”. The respondents were asked to select the level of effectiveness of the strategies based on their work experience.

The population was based on the list from the 2010 ROC National Association of Shipping Agencies in Taiwan, and all 116 container shipping companies in the list were included. Managers from three departments in each company were selected, including the information/documentation department, the physical/operations department and the financial/accounting department. This is because these three departments cover the main risk management issues that arise in container shipping operations. However, some companies did not have all three of these departments. After recalculating the population size, the final effective sample size was 342. After collecting the replies, the rank of these strategies could then be obtained.

3.3 Evaluation of the relative importance of risk mitigation strategies
There are a number of methods for multiple criteria decision making, yet there are some limitations for these methods such as some methods need a large scale of questionnaire replies, some of their purposes are not suitable for our research aim, and some of them need high computer language design skills and extensive quantitative data (Qu et al., 2017). As this study is relating to empirical research and has a relatively limited population to investigate, we decided using AHP as the method to evaluate the relative importance of risk mitigation strategies. AHP proposed by Saaty (1988) has been widely used to evaluate the relevant importance of decision criteria/alternatives in various industries including maritime and port (Ha et al., 2017). The basic concept of the AHP is to assist decision making through a hierarchical structure with different criteria and sub-criteria that are weighed through pairwise comparisons (Wang et al., 2015). Chang et al. (2014) proposed a structure with three risk categories (i.e. financial risk, reputation risk and safety and security risk), whereas the criteria in our study are adapted from this structure and amended as reducing financial loss, reducing reputation loss and reducing safety and security incident related loss. Four axioms of the AHP are assumed in its applications, including reciprocal comparison, homogeneity, dependence and expectations (Saaty, 1988). Reciprocal comparison means that when making paired comparisons, both members of the pair must be considered to judge the relative value. Homogeneity means that when the disparity is great, the elements are placed in separate clusters of comparable size giving rise to the idea of levels and their accommodation. Dependence means that the smaller elements depend on the outer parent elements to which they belong, in a large hierarchical cluster. Expectations

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are beliefs about the rank of alternatives derived from prior knowledge (Saaty and Kulakowski, 2016). The data were examined and matched to the four axioms.

While the AHP method can be used in many areas (Saaty, 1988; Ho, 2008), it has been criticised in a number of studies (Chang, 1996; Bana e Costa and Vansnick, 2008; Wang et al., 2015). Among the critics, the most common is uncertainty in terms of subjective perception (Chan and Kumar, 2007), which may result in an inaccurate measurement. Respondents may be confused, and hence, provide inconsistent answers when being asked to do pair comparisons or may also result in a lack of data when respondents fail to answer some questions (Wang et al., 2015). To overcome the weakness related to uncertainty, Zadeh (1965) proposed the fuzzy set theory, which fuzzifies the respondents’ perceived value by considering that human beings cannot always perceive exact values. Based on this, Laarhoven and Pedrycz (1983) proposed a fuzzy AHP method by adapting fuzzy numbers (e.g., triangular/trapezoidal) from the fuzzy set theory into the AHP method. With the advantage of fuzzy set theory, the fuzzy AHP, thus, overcomes the shortcomings of the AHP and has become a widely accepted method in multiple criterion decision making under uncertainty. In the maritime area, a number of studies have used the fuzzy AHP to carry out their investigations. For example, Ding (2010) addressed the critical factors, which affect customer value for shipping companies from a customer perspective. Ka (2011) used the fuzzy AHP to determine selection of locations for China’s dry ports. Yang and Chung (2013) applied the fuzzy AHP to find preferred ship flag registry locations among Taiwan, Hong Kong and China. This study, therefore, also uses the fuzzy AHP method to cope with the subjective perceptions of respondents. To keep the research task at a manageable scale, a set of the most important risk mitigation strategies are selected from the results of the “mitigation-strategy survey” to conduct a further survey evaluation, namely, the fuzzy AHP survey:

A fuzzy AHP analysis includes the following eight main phases (Buckley, 1985; Ding, 2010; Ding and Tseng, 2012):

1. Develop a hierarchical structure with three criteria and six alternatives:

   In this study, the hierarchy structure included three major levels, namely, goal, criteria and alternatives. The goal refers to “mitigating risks in shipping operations”. Three criteria corresponding to three risk consequences were identified as “reducing financial losses”, “reducing reputation loss” and “reducing safety and security incident-related losses”. The alternatives included a set of the most important risk mitigation strategies selected from the results of the mitigation-strategy survey. The number of selected strategies is usually less than seven, as the brains of human beings cannot compare more than seven items at the same time:

2. Collect pairwise comparison matrix of decision elements:

   Let $x_{ij}^h$, $h = 1, 2, \ldots, 12$, be the relative importance given to reducing risk consequence $i$ compared to reducing risk consequence $j$ by expert $h$ at the criteria level; let $x_{st}^h$, $h = 1, 2, \ldots, 12$, denote the relative importance given to risk mitigation strategies $s$ compared to risk mitigation strategies $t$ by expert $h$ at the alternative level:

3. Transform relative importance into a triangular fuzzy number (TFN):

   TFN combines the minimum value (denoted by $l$), maximum value (denoted by $u$) and mean value (denoted by $m$) of the opinions of all experts. The meaning of TFN used in the fuzzy AHP is presented in Table II.
(4) Build a fuzzy positive reciprocal matrix:

The TFN was used to build a fuzzy positive reciprocal matrix. To illustrate the TFN application, the results of one respondent are shown below. There are three criteria at the criteria level; thus, the fuzzy positive reciprocal matrix is a $3 \times 3$ matrix that can be generated by:

$$
\tilde{B}^C_{i,j} = \begin{bmatrix}
\tilde{1} & \tilde{B}_{12}^C & \tilde{B}_{13}^C \\
1/\tilde{B}_{12}^C & \tilde{1} & \tilde{B}_{23}^C \\
1/\tilde{B}_{13}^C & 1/\tilde{B}_{23}^C & \tilde{1}
\end{bmatrix} = \begin{bmatrix}
(1, 1, 2) & (1, 1, 2) & \left(\frac{1}{2}, \frac{1}{3} \right) \\
(1, 1, \frac{1}{2}) & (1, 1, 2) & \left(\frac{1}{2}, \frac{1}{3}, \frac{1}{4} \right) \\
(1, 2, 3) & (2, 3, 4) & (1, 1, 2)
\end{bmatrix},
$$

where $\tilde{B}_{i,j}^C$ represents the TFN of the relative importance of reducing risk consequence $i$ over reducing risk consequence $j$, $\tilde{B}_{i,j}^C \otimes \tilde{B}_{i,j}^C = 1$, $\forall i, j = 1, 2, 3$, where $i = 1$ or $j = 1$ means reducing financial loss; $i = 2$ or $j = 2$ means reducing reputation loss; and $i = 3$ or $j = 3$ means reducing safety and security-related incident loss:

(5) Calculate the fuzzy weights of the fuzzy positive reciprocal matrices.

The method for calculating the fuzzy weights $\tilde{W}$ is separated into two steps: calculate the geometric mean $\tilde{Z}_i$ and $\tilde{Z}_s$ of the fuzzy comparison value of reducing risk consequence $i$ and alternative $s$; and calculate the fuzzy weight $\tilde{W}_i$ and $\tilde{W}_s$ of the reducing risk consequence $i$ and alternative $s$. At the criteria level, we use the criterion “reducing financial loss” as the example, where the geometric mean of TFN of the $i$-th criterion can be given by:

$$
\tilde{Z}_i^C = \sqrt[3]{(\tilde{B}_{i1}^C \otimes \tilde{B}_{i2}^C \otimes \ldots \otimes \tilde{B}_{i3}^C)} = \sqrt[3]{(0.33, 0.5, 1)}, \quad \forall i = 1, 2, and 3
$$

and the fuzzy weight of the $i$-th criterion is given by:

$$
\tilde{w}_i^C = \tilde{Z}_i^C \otimes \left(\tilde{Z}_1^C \otimes \tilde{Z}_2^C \otimes \ldots \otimes \tilde{Z}_k^C\right)^{-1} = (0.13, 0.24, 0.65)
$$

<table>
<thead>
<tr>
<th>Meaning</th>
<th>Triangular fuzzy no.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equally preferred</td>
<td>$\tilde{1}$ = (1,1,2)</td>
</tr>
<tr>
<td>Equally to moderately preferred</td>
<td>$\tilde{2}$ = (1,2,3)</td>
</tr>
<tr>
<td>Moderately preferred</td>
<td>$\tilde{3}$ = (2,3,4)</td>
</tr>
<tr>
<td>Moderately to strongly preferred</td>
<td>$\tilde{4}$ = (3,4,5)</td>
</tr>
<tr>
<td>Strongly preferred</td>
<td>$\tilde{5}$ = (4,5,6)</td>
</tr>
<tr>
<td>Strongly to very strongly preferred</td>
<td>$\tilde{6}$ = (5,6,7)</td>
</tr>
<tr>
<td>Very strongly preferred</td>
<td>$\tilde{7}$ = (6,7,8)</td>
</tr>
<tr>
<td>Very strongly to extremely preferred</td>
<td>$\tilde{8}$ = (7,8,9)</td>
</tr>
<tr>
<td>Extremely preferred</td>
<td>$\tilde{9}$ = (8,9,9)</td>
</tr>
</tbody>
</table>

Table II. TFN of Fuzzy AHP
To simplify the notation, the fuzzy weight can be further denoted by:

\[ \tilde{w}_i^C = (w_{ii}^C, w_{im}^C, w_{iu}^C) \]

(6) Defuzzify the fuzzy weights to crisp weights:

After obtaining the fuzzy weights, we converted them into crisp ones using a centroid defuzzification method (Ali et al., 2012).

(7) Standardise the crisp weights:

To facilitate the comparison of the relative importance between criteria, the obtained crisp weights (in Step 6) are standardised by:

\[ S_{w_i}^C = \frac{w_i^C}{\sum_{i=1}^{n} w_i^C} \quad \text{for the criteria.} \]

(8) Calculate the integrated weight for each level:

After standardising the crisp weights, the integrated weight for each criterion is computed by taking into account the weight at the current level and its upper level. More specifically,

The integrated weights of each criterion at the criteria level are given by (note that the weight at its upper level is 1):

\[ Iw_i^C = Sw_i^C, \quad \forall i = 1, 2, 3, \]

4. Data analysis

4.1 Respondents’ profile and validity and reliability test

According to Davis (2005), several common methods are used to enhance the level of validity, including careful identification of the measurement items from the literature and an expert interview to validate the identified items. The questions in the mitigation-strategy survey were designed based on the literature review and were validated through the seven face-to-face interviews to ensure a high level of validity.

After collecting the replies from the mitigation-strategy survey, we identified 62 (out of 88 replies) valid and 26 invalid feedbacks. The valid response rate was 18.13 per cent. The 62 respondents’ profile in the survey is presented in Table III. The results show that approximately 80 per cent of respondents has work experience more than 10 years. The respondents’ department include President/vice-president, information/document, financial/accounting and operation/shipping department. For the position, there is an approximate 80 per cent of respondents who are vice director or above. A reliability test was conducted for the questions on risk mitigation strategies, for which the Cronbach’s alpha was 0.872 (>0.8). It indicated that the designed questions on risk mitigation strategies were reliable.

4.2 Ranking of risk mitigation strategies

Table IV shows the results of the different risk mitigation strategies based on the data from the risk-mitigation survey. Based on the mean score, the top six strategies include “form alliances with other shipping companies” (mean score: 4.02); “use more advanced infrastructures and technologies (hardware and software)” (mean score: 3.92); “choose partners more carefully” (mean score: 3.87); “enter into long-term contracts with shippers”
<table>
<thead>
<tr>
<th>Work experience</th>
<th>No.</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-5 years</td>
<td>9</td>
<td>14.5</td>
</tr>
<tr>
<td>6-10 years</td>
<td>4</td>
<td>6.5</td>
</tr>
<tr>
<td>11-15 years</td>
<td>3</td>
<td>4.8</td>
</tr>
<tr>
<td>16-20 years</td>
<td>12</td>
<td>19.4</td>
</tr>
<tr>
<td>21-25 years</td>
<td>17</td>
<td>27.4</td>
</tr>
<tr>
<td>Over 25 years</td>
<td>17</td>
<td>27.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Department</th>
<th>No.</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>President/vice-president</td>
<td>7</td>
<td>11.3</td>
</tr>
<tr>
<td>Information/document</td>
<td>8</td>
<td>12.9</td>
</tr>
<tr>
<td>Financial/accounting</td>
<td>12</td>
<td>19.4</td>
</tr>
<tr>
<td>Operation/shipping</td>
<td>30</td>
<td>48.4</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>8.1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Position</th>
<th>No.</th>
<th>(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vice president or above</td>
<td>8</td>
<td>12.9</td>
</tr>
<tr>
<td>Manager/Assistant manager</td>
<td>22</td>
<td>35.5</td>
</tr>
<tr>
<td>Director/Vice Director</td>
<td>18</td>
<td>29.0</td>
</tr>
<tr>
<td>Clerk</td>
<td>10</td>
<td>16.1</td>
</tr>
<tr>
<td>Sales representative</td>
<td>3</td>
<td>4.8</td>
</tr>
<tr>
<td>Others</td>
<td>1</td>
<td>1.6</td>
</tr>
</tbody>
</table>

**Table III.** Respondents' profile

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Mean</th>
<th>SD</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be flexible when designing the timetable/schedule, e.g. include time buffers</td>
<td>3.81</td>
<td>0.76</td>
<td>6</td>
</tr>
<tr>
<td>Implement slow steaming and increase the number of ships on existing routes</td>
<td>3.52</td>
<td>0.82</td>
<td>1</td>
</tr>
<tr>
<td>Use more advanced infrastructures (hardware and software)</td>
<td>3.92</td>
<td>0.66</td>
<td>2</td>
</tr>
<tr>
<td>Improve safety measures, such as by implementing safety rules and regulations such as the IMDG Code and ISM Code</td>
<td>3.71</td>
<td>0.76</td>
<td>3</td>
</tr>
<tr>
<td>Improve security measures, such as by implementing security rules and regulations such as the ISO 27001 and ISPS Code</td>
<td>3.58</td>
<td>0.78</td>
<td>4</td>
</tr>
<tr>
<td>Execute Regular employee training (e.g. once a year or twice a year)</td>
<td>3.66</td>
<td>0.77</td>
<td>5</td>
</tr>
<tr>
<td>Avoid having too many partners</td>
<td>3.29</td>
<td>0.71</td>
<td>6</td>
</tr>
<tr>
<td>Choose partners very carefully</td>
<td>3.87</td>
<td>0.66</td>
<td>7</td>
</tr>
<tr>
<td>Shorten/withdraw contracts with partners who perform badly</td>
<td>3.52</td>
<td>0.72</td>
<td>8</td>
</tr>
<tr>
<td>Build trust with partners</td>
<td>3.65</td>
<td>0.77</td>
<td>9</td>
</tr>
<tr>
<td>Cultivate loyalty among supply chain partners</td>
<td>3.77</td>
<td>0.80</td>
<td>10</td>
</tr>
<tr>
<td>Reward/assist partners that comply with shipping line initiatives</td>
<td>3.58</td>
<td>0.69</td>
<td>11</td>
</tr>
<tr>
<td>Enter into long-term contracts with shippers</td>
<td>3.85</td>
<td>0.76</td>
<td>12</td>
</tr>
<tr>
<td>Share information with partners without co-management (cooperation level)</td>
<td>3.65</td>
<td>0.66</td>
<td>13</td>
</tr>
<tr>
<td>Exchange ideas with partners to solve conflicts or improve service quality (coordination level)</td>
<td>3.77</td>
<td>0.66</td>
<td>14</td>
</tr>
<tr>
<td>Collaborate with partners (e.g. port operators, inland transportation operators) through making joint long-term plans (collaboration level)</td>
<td>3.85</td>
<td>0.67</td>
<td>15</td>
</tr>
<tr>
<td>Form alliances with other shipping companies</td>
<td>4.02</td>
<td>0.67</td>
<td>16</td>
</tr>
<tr>
<td>Acquire and merge with other shipping companies</td>
<td>2.95</td>
<td>0.76</td>
<td>17</td>
</tr>
</tbody>
</table>

**Notes:** SD = Standard Deviation; strategy 4, 5, 8, 11 are obtained from interviews and presented in Italic

**Table IV.** Risk mitigation strategies
The strategy “acquire and merge with other shipping companies” (mean score: 2.95) had the lowest score among all mitigation strategies. As this strategy has a long-term, significant impact on shipping company operations, it often implies a high degree of uncertainty and may only be adopted in critical situations. On the other hand, it is interesting to observe that the recent popular practice of slow steaming had a relatively low score among these strategies. Slow steaming can reduce fuel consumption and absorb the idle capacity, which is an appropriate strategy for shipping lines when supply exceeds demand. However, it increases transit time and could cause extra inventory costs to shippers. The low score for slow steaming with the highest S.D. indicates that the respondents’ opinions were very different. Some of the respondents felt that slow steaming is a realistic strategy to reduce risks within container shipping operations, while the others hold an opposite opinion.

When considering the three different “cooperation” levels (Strategies 14, 15 and 16), the results show that collaboration level had the highest mean score with 3.85, followed by coordination level (mean score: 3.77), and cooperation level has the lowest mean score with 3.65. This indicates that shipping companies will have better risk mitigation effects if the companies have a higher level of “cooperation” relationships with partners.

To evaluate the priority of these mitigation strategies under the three criteria (i.e. reducing financial loss, reducing reputation loss and reducing safety and security incident-related loss), the top six strategies were selected for a further step by conducting the fuzzy AHP. The reason for selecting the top six strategies is because the human being’s brain will be confused when comparing more than seven items (Saaty, 1977). In addition, several studies also suggested that to serve both consistency and redundancy to the AHP method, it is best to keep the number of criteria and alternatives at seven or less (Saaty and Ozdemir, 2003; Russo and Camanho, 2015). In this study, there are two strategies ranked at the seventh among the 18 ones, we thus selected six strategies. As shown in Table IV, the six selected strategies include: “form alliances with other shipping companies” (renamed as Strategy A for the fuzzy AHP analysis in Section 4.3); “use more advanced infrastructures (hardware and software)” (Strategy B); “choose partners very carefully” (Strategy C); “collaborate with partners (e.g. port operators, inland transportation operators) through making joint long-term plans (collaboration level)” (Strategy D); “enter into long-term contracts with shippers” (Strategy E) and “flexible design of the timetable/schedule, e.g. include time buffers” (Strategy F).

### 4.3 Fuzzy AHP analysis

After building the hierarchy structure, paired comparisons were conducted for the fuzzy AHP survey. The purpose was to evaluate the relative importance of the different criteria and different alternatives in the fuzzy AHP model. The population size for the fuzzy AHP survey was still 342 in this study, (i.e. the same as that for the mitigation-strategy survey); however, the sampling process was different. To increase the return rate, all respondents to the first questionnaire survey were selected. In addition, some key managers from the non-responding list were also selected. Finally, a total of 114 questionnaires were sent out and 21 replies were received; including 12 valid ones and 9 invalid ones. The valid return rate was 10.53 per cent. Microsoft Office Excel software was then used to conduct the fuzzy AHP analysis. The results show the consistency ratio (CR) of each criterion to be 0.01, which is
less than the standard acceptable value (0.1). Therefore, the data met the consistency requirement. After confirming the requirement.

The weights of the criteria and strategies were calculated by averaging the weight value of the 12 respondents’ perceived value. In addition, by combining the criterion priorities and the relevant alternative priorities, we were able to obtain an overall priority ranking of the decision alternatives shown in Table V.

Table V shows that the weights of the criterion “reducing financial loss” (0.424) and “reducing safety and security incident-related loss” (0.420) are much greater than “reducing reputation loss” (0.156). This indicates that the first two criteria are more important under the goal of mitigating risks in shipping operations. It is easy to understand that almost every company pays a lot of attention to reducing financial loss. However, “reducing safety and security incident-related loss” is also important in container shipping operations due to the dangerous work environment. Compared to retailer operations in which maintaining reputation and brand are of high priority (Dawar and Parker, 1994), container shipping operations tend to focus more on financial loss reduction and safety and security incident-related loss reduction.

Under the criterion “reducing financial loss”, Strategy E: “Enter into long-term contracts with shippers” and Strategy A: “Form alliances with other shipping companies” are the top two strategies for mitigating financial loss in container shipping operations. These two strategies can be used to tackle and reduce the risk caused by transportation demand uncertainty. Moreover, the global importance of Strategy E (0.108) was twice more than the one of Strategy F (0.048).

Under the criterion “reducing reputation loss”, Strategy A: “Form alliances with other shipping companies” was evaluated as the most important strategy. However, the variation

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Weights of criteria (a)</th>
<th>Strategies</th>
<th>Weights of strategies (b)</th>
<th>Global weights (a)* (b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reducing financial loss</td>
<td>0.424</td>
<td>A 0.189</td>
<td>0.080</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B 0.142</td>
<td>0.060</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 0.134</td>
<td>0.061</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 0.156</td>
<td>0.066</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E 0.255</td>
<td>0.108</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F 0.114</td>
<td>0.048</td>
<td></td>
</tr>
<tr>
<td>Reducing reputation loss</td>
<td>0.156</td>
<td>A 0.204</td>
<td>0.032</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>B 0.169</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 0.181</td>
<td>0.028</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 0.165</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E 0.164</td>
<td>0.026</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F 0.117</td>
<td>0.018</td>
<td></td>
</tr>
<tr>
<td>Reducing safety and security</td>
<td>0.420</td>
<td>A 0.213</td>
<td>0.089</td>
<td></td>
</tr>
<tr>
<td>incident-related loss</td>
<td></td>
<td>B 0.188</td>
<td>0.079</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>C 0.173</td>
<td>0.073</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>D 0.162</td>
<td>0.068</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>E 0.153</td>
<td>0.064</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>F 0.110</td>
<td>0.046</td>
<td></td>
</tr>
</tbody>
</table>

Notes: A: Form alliance with other shipping companies. B: Use more advanced infrastructure (hardware and software). C: Choose partners more carefully. D: Cooperate with your partners (e.g. terminal operational company, inland transportation). E: Make a long-term contract with shippers. F: Design a flexible shipping schedule. [n] n is the rank of the strategy under each criterion.
of the weights of the six strategies under this criterion was insignificant, indicating their contributions to reducing reputation loss have no vast difference.

Under the criterion “reducing safety and security incident-related loss, Strategy A: “Form alliances with other shipping companies” was calculated as the most important risk mitigation strategy, and its global weight (0.089) doubled that of Strategy F (0.046).

To understand the importance of the mitigation strategies over all three criteria, we calculated the overall priority of each strategy, by calculating the sum of the global weights of each strategy under three criteria. The calculations of the overall priority of individual strategies are as follows:

\[
\text{Overall priority of Strategy A} = 0.424 \times 0.189 + 0.156 \times 0.204 + 0.420 \times 0.213 = 0.202
\]

In a similar way, the overall priority values of strategies B to F are obtained as 0.165, 0.162, 0.160, 0.197 and 0.112, respectively. Such a result reveals that from the overall perspective, the best risk mitigation strategies are strategies A and E, while the worst is strategy F. Strategies B to D of a priority value around 0.16 present a large distance to both best and worst strategies. It, therefore, can help ship lines to rationalise and justify their safety resources on different risk mitigation strategies with respect to the priority values.

5. Discussion and conclusions

Compared to other studies addressing risk management in general manufacturing industries or examining only one or a few risk mitigation strategies in container shipping operation, this study considered risk management in container shipping with three risk consequences. We identified and confirmed 18 typical risk mitigation strategies through a literature review and interviews, in which the interviews contributed four new strategies not mentioned in the existing literature.

Through the mitigation-strategy questionnaire survey, we were able to rank the mitigation strategies according to their overall effectiveness. The results show that the top six strategies include “form alliances with other shipping companies”, “use more advanced infrastructures (hardware and software)”, “choose partners more carefully”, “enter into long-term contracts with shippers”, “collaborate with partners (e.g. port operators, inland transportation operators) through making joint long-term plans” and “flexible design of the timetable/schedule, e.g. include time buffers”; whereas the strategy “acquire and merge with other shipping companies” had the lowest score among all mitigation strategies.

The six most important strategies were then selected to conduct an AHP survey to compare their relative importance in terms of three different criteria: reducing financial loss, reducing reputation loss and reducing safety and security incident-related loss. The AHP survey and the AHP analysis yielded the results. Firstly, it was found that container shipping companies tend to place more emphasis on “reducing financial loss”, yet they also pay a lot of attention to “reducing safety and security incident-related losses”. However, the results showed that in average container shipping companies do not place much emphasis on “reducing reputation loss” compared to the first two criteria. The implication is that the top mitigation strategies probably have a more significant and direct impact on the first two criteria. In Taiwan case, given today’s shipping business climate, even large companies pay more attention to mitigating financial loss as evidenced by our findings. It is different from previous studies, which were conducted in a better global financial situation. It stimulates a new research question that if the global shipping market situation has impact on the shipping companies’ risk mitigation strategies. Secondly, it was also found that “forms alliance with other shipping companies” and “enter into long-term contracts with shippers”
are the top two strategies for risk mitigation in shipping operations. It is, therefore, suggested that container shipping companies pay more attention to making good relationships with their alliance partners or even their competitors to co-mitigate the impacts of the associated risks. Thirdly, it is often the case that a shipping company has restricted recourses to implement all the identified 18 strategies. It is very essential to choose control strategies with priority. Hence, this study investigated the first six strategies to prioritise them for recommendation, as well as to demonstrate how the remained strategies can be further evaluated by shipping companies to meet their own needs.

Based on the results of the fuzzy AHP, the six strategies were ranked according to their overall priority as follows: A, E, B, C, D and F. This ranking has a notable difference (for Strategy E) compared to the result from the mitigation-strategy survey, where the ranking order was A, B, C, D, E and F. This may be due to the fact that container shipping is a logistics service provider industry, which does not have its own production, and the profit relies totally on the transportation demand from shippers. Therefore, making long-term contracts with shippers can reduce future demand uncertainty and ensure that shipping companies will have a certain volume of promised cargo to transport. It should also be pointed out that the AHP survey compared the selected strategies against three different criteria separately, whereas the mitigation-strategy survey only considered the overall impact of the strategies. The overall priority of Strategy A “form alliances with other shipping companies” exhibited the largest overall priority of 0.202, which infers that it plays the most important role in reducing container shipping operation risks. This was followed by Strategy E: “enter into long-term contracts with shippers”, which also had a priority of 0.197. Note that the weights of the middle three strategies (i.e. B, C and D) were fairly close; the six strategies could thus be divided into three groups. That is, Group 1 comprises Strategies A and E, which have the highest impact on reducing the container shipping operational risks; Group 2 includes Strategies, B, C and D that have a medium impact and Group 3 comprises only Strategies F, which has the lowest impact on mitigating the container shipping operational risks. More specifically, the weight of Strategy A (0.202) in Group 1 is about two times that of the weight of Strategy F (0.112) in Group 3, and the weights of the alternatives in Group 2 are around one and half times that of Strategy F. Comparing the above result with the overall effectiveness ranking from the first survey, they are generally consistent with the exception of Strategy E, which held second place among the six strategies.

Although this research achieved its aims and objectives, there are several limitations in this study: seven face-to-face interviews involved in this research. This was caused by time constraints and the difficulties in involving senior shipping managers. It would be better if more managers were involved in the interviews. However, the interviews involved managers who work in the three main departments, so it is believed that the interview results had reasonable reliability. We obtained 62 valid questionnaire replies in the mitigation-strategy survey. It is, of course, suggested that more valid questionnaire replies will lead to more accurate results. More valid questionnaire replies can be achieved by sending a second round of the same questionnaire survey. Although we conducted a reliability test to prove the results of this questionnaire to be reliable, it is still suggested that future researchers collect a larger number of responses so as to improve the study’s reliability and validity. This work uses the container shipping industry in Taiwan as a case study. It is believed that the results would be more accurate if we could interview and do the questionnaire survey in international container shipping companies outside of Taiwan. Nevertheless, our results could be generalised to many international container shipping companies for the following two reasons: the interviewees include the managers of Taiwan’s
container shipping companies in the UK. Through their point of view, the risk factors and risk mitigation strategies in container shipping operations could be generalised to international container shipping companies. Although the respondents of the two surveys work in Taiwan, their companies are also regarded as international companies as they have branches of their company in other countries or their agents work for international container shipping companies. The findings based on a single perspective (i.e. importance of the strategies representing the effectiveness in terms of risk consequence reduction) can be further investigated by the incorporation of cost analysis of each strategy so that ship lines can choose the most cost effective strategies. This study analyses the importance of the strategies, but it is also important to evaluate their financial feasibility. It is suggested to conduct a cost-benefit analysis in future similar research.

It is believed that, through this paper, container shipping managers can have more options to deal with risk management, and they understand how to prioritise strategies with respect to different types of risk consequences. In the academic area, this paper can also fill gaps in previous studies related to comparisons of risk mitigation strategies from the perspective of different levels of cooperation.

Note
1. *Table IV contains more analytical results from mitigation-strategy survey, hence being presented in Section 4.2.

References


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