Research Highlight 1: Evaluation of Port Efficiency System for Ports along the Yangtze River , By Ms Song Chunxue (Track Leader: A/Prof Anthony Chin)

Problem Statement

Port efficiency is a crucial indicator of port productivity, port performance and even port competitiveness. Many scholars and researchers endeavored to evaluate ports' efficiency with a variety of indicators and methodologies, within which overall efficiency, technical efficiency and scale efficiency were respectively unraveled. The problem is that efficiency is a relative, comparative and often a subjective value. Another notable point is as aforementioned that different authors may have a different definition of a certain criterion which makes a virtual comparison actually impossible.

Economic Context

With the phenomenal development over past decades, China's coastal ports dwarf inland ports in terms of both overall throughput and its growth. However, as a predominant access to hinterland, Yangtze River, to a great extent representing China's inland shipping, is incomparable with respect to comparatively low investment, low costs, high capability, less land occupation, high safety and security, better energy saving, low emissions and environment friendly, etc. For instance, the unit costs among Yangtze River, railway and highway is 1:2:6, while the energy saving among these three transport modes is 1:1.8:5.0. Recently, having been fermenting for nearly 30 years, China's government raised the construction of Yangtze River economic belt to a level of national strategy in public, which comprising 9 provinces and 2 municipalities, more than the original 7 provinces and 2 municipalities. The newly defined economic belt, or addressed as economic corridor, will involve 11 regions including Shanghai, Jiangsu, Zhejiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Chongqing, Yunnan and Guizhou, with Zhejiang and Guizhou Province just added in. As shown in Figure 1, the dark parts delineate the aforementioned 11 regions of Yangtze River economic belt, and the blue line indicates the Yangtze River boundary. This newly programmed economic corridor accounts for about 18 percent of the national land area, 36 percent of the total national population and 45 percent of nationally holistic GDP. Through China's reforms and opening-up, as well as some key projects, three "blocks" in the Yangtze River economic belt are expected to be invigorated, including the delta(mainly denotes the lower stream), city clusters along the central course and the Chengdu-Chongqing economic zone, which we could easily make clear from Figure 1. With the aim of lessening this imbalance and boosting the interior economy to rebalance toward a more stable and sustainable growth model, China takes the initiative to inject more funding, technology and manpower towards the Yangtze River ports and improve their efficiency to accelerate the industrial activity migration from the coast to the interior, which will consequently and surely generate ballooning demand and thus vast potential to this Yangtze River, as is metaphorized Golden Waterway.

Fig.1 Three city clusters along the Yangtze River economic

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Concept

As times move forward, more and more countries gradually recognized the colossal importance of ports to their foreign trade, or even their economy in terms of cost and worldwide accessibility, etc. New port functions establishment are in urgent need to cater for the needs of their customers and assist them in improving their competitive positions by providing low-cost, efficient port service. Figure 2 shows the intrinsic mechanism connection between port function and foreign trade.

With such recognition and this has generated port services with other components of the global distribution network. Meanwhile, as a result of the new pattern of international labor division and evolvement of ports functioning (as depicted in Figure 2), ports' economic relationship are no longer confined within inside. To this end, a new concept system of port efficiency is supposed to involve the Operative Efficiency within a port per se, the Network Configuration Efficiency between a port and other ports, and the Radiant Efficiency between and its hinterland, namely Port Efficiency, and respectively. These three levels of port efficiency are inseparable, and interact with each other. Port efficiency could be delineated within the connotation of port efficiency system (as indicated in Figure 3). This research delineates efficiency of ports along the Yangtze River on the three important aspects within the connotation of port efficiency system:

(1) Port Efficiency I: It denotes the intrinsic operational efficiency of individual port, and this is the foundation of the whole port efficiency system. This level of efficiency is supposed to be reflected by the utilization of various inputs relative to productivity.

(2) Port Efficiency II: Based on Port Efficiency I, the intra-ports economic connection is another imperative section of the overall port efficiency system. This level of efficiency is regarded as the utilization of various inputs relative to productivity within the economic network between one port to another.

(3) Port Efficiency III: On the ground of Port Efficiency I and II, the economic connection between ports and their hinterland is also an important composition.
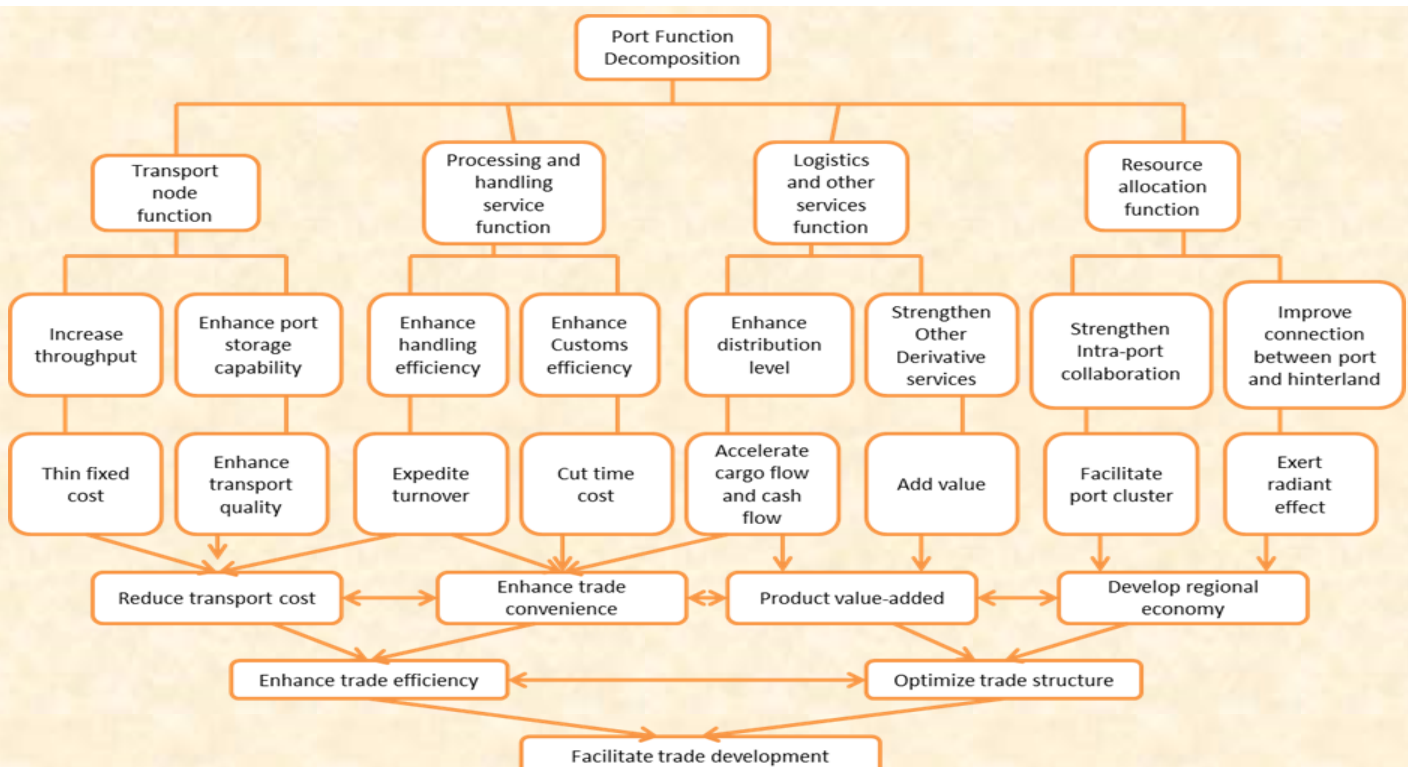

Fig. 2 Port Function Decomposition and its influence mechanism to foreign trade, Source: The World Economic Forum, 2011

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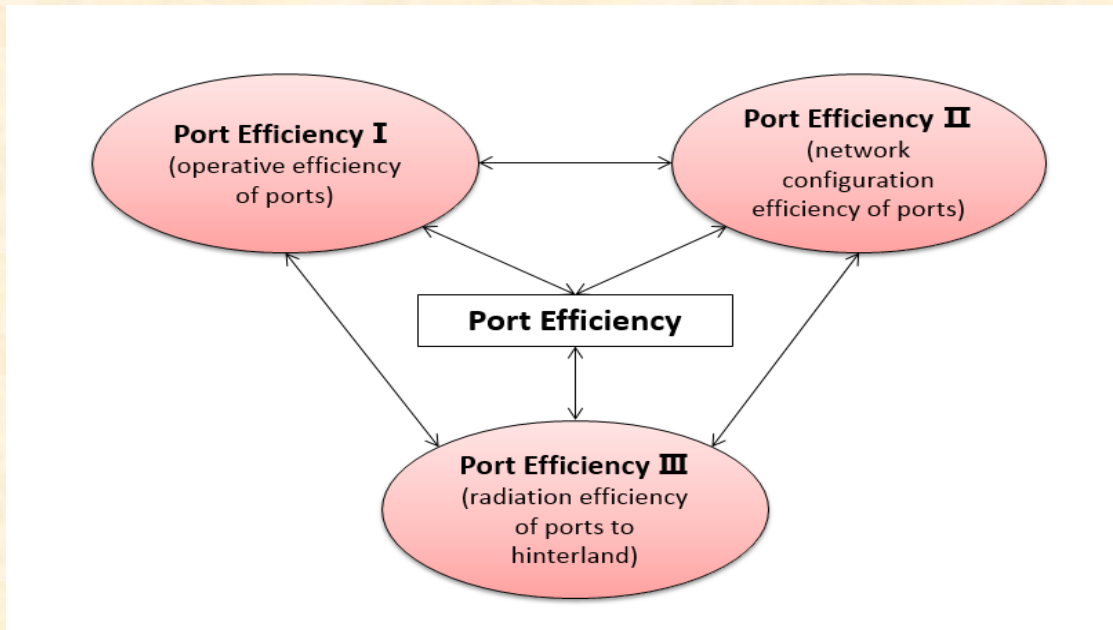
Concept

Fig.3 the three important aspects within the port efficiency system

Methodology

We will adopt DEA technique to evaluate the ports' efficiency based on the main input and output data of ports along the Yangtze River. The results will help us to judge whether these assessed ports can research DEA efficiency on these three levels respectively and even present the causes of inefficiency, if any.

a. Model Specification

Each observed port is deemed as a DMU (Decision-making unit); Suppose there are n DMUs, represented by DMU_j, $1 \leq j \leq n$;

There are m inputs and s outputs, then the input and output parameters can be expressed as : $x_j = (x_{1j}, x_{2j} \ldots x_{mj})T$, $y_j = (y_{1j}, y_{2j}, \ldots, y_{sj})T$, $j = 1, 2, \ldots, n$;

Let v_i and u_r denote the measurements of the ith input and rth output respectively, v and u are the weight coefficients, then $v = (v_1, v_2, \ldots v_i, \ldots v_m)T$, $u = (u_1, u_2, \ldots u_r, \ldots, u_s)T$;

For each DMU, its efficiency evaluation index is:

Here, we denote j0th DMU with DMU_{j0}, and its input and output is denoted by X_{j0}, Y_{j0}. Generally speaking, the higher h_{j0} is, the more output will be generated with comparatively less input.

Therefore, the assessment of DMU_{jo} efficiency is actually a problem of judging whether the solution is an optimum solution among these n DMUs, or trying to obtain the maximum of h_{jo} when we change the given weights. Thus, the target is the efficiency index of the jth DMU and put all the DMU efficiency indexes as constraints. By doing so, we can construct the following optimization equation, namely C2R model:

$$h_j = \frac{u^T y_j}{v^T x_j} = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}}, j = 1, 2, \ldots n$$

$$\begin{cases} \max h_{j0} = \dfrac{u^T y_{j0}}{v^T x_{j0}} \\ s.t\, h_j = \dfrac{u^T y_j}{v^T x_j} \leq 1, j = 1, 2, \ldots n \end{cases}$$

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Methodology

Through the Charnes-Cooper transformation, we can transform the linear optimization model, and thus take into the consideration of s- and s+, the signs denoting the input and output, leading to the following C2R model which includes the Archimidean infinitesimal Epsilon:

$$(D_\varepsilon)\begin{cases} \min\left[\theta - \varepsilon(e_1^T s^- + e_2^T s^+)\right] \\ s.t.\sum_{j=1}^{n}\lambda_j x_j + s^- = \theta x_0 \\ \sum_{j=1}^{n}\lambda_j y_j - s^+ = y_0 \\ \lambda_j \geq 0, j = 1, 2, \ldots n \\ s^+ \geq 0, s^- \geq 0 \end{cases}$$

b. Indicators Selection

Based on the above concept of port efficiency system, we establish the evaluation indicators for the Yangtze River ports as below (shown in Table 1)

Port efficiency layer		indicators
Port Efficiency Ⅰ:	Input X	1. berth quantity
		2. total length of berth
		3. largest depth of apron
		4. number of quay cranes
	Output Y	1. cargo throughput(foreign trade)
Port Efficiency Ⅱ:	Input X	1. number of liner shipping routes to other ports(domestic and foreign trade incl.)
		2. Liner schedule intensity
	Output Y	1. cargo throughput(foreign trade)
Port Efficiency Ⅲ:	Input X	1.volume(turnover) of railway freight between port and hinterland
		2.volume(turnover) of road freight between port and hinterland
		3. volume(turnover) of river freight between port and hinterland
	Output Y	1. cargo throughput (foreign trade)
		2. trade volume(value)of direct hinterland
		3. GDP of direct hinterland

Tab. 1 Input and output indicators of port efficiency

c. Data Collection

We choose the top 10 container ports (ranked in 2012) along the Yangtze River as observed objects. They are Suzhou Port, Nanjing Port, Jiangyin Port, Wuhan Port, Nantong Port, Chongqing Port, Zhenjiang Port, Yangzhou Port, Wuhu Port and Jiujiang Port, ranked as above by the container throughput performance in 2012.

Most of the secondary data were retrieve from<China Yearbook>, <China Port Yearbook>, provincial yearbook, and<China's Transportation Yearbook> etc., while some raw data were obtained from corresponding Port Authorities by telephone interviews, and so on and so forth.

Research Highlight 2: Zero-Inflated Poisson Distribution Model of the Occurrence Pattern of Piracy
By Mr Huang Daozheng (Track Leader: A/Prof Meng Qiang)

Objective

The objective of this study is to predict the occurrence of piracy. In order to formulate the occurrence of piracy, the paper assumes that the number of piracy in one day is a random variable and then tries to estimate the probability mass of the variable.

Poisson Distribution Test

The hypothesis that accident occurrence patterns follow Poisson distribution is regularly adopted by many researchers. In this study, the sample size is 3653, which is large enough that Poisson distribution can be an approximation of binomial distribution if n is sufficiently large and p is sufficiently small.

The Poisson distribution is a good approximation of the binomial distribution if n is at least 20 and p is smaller than or equal to 0.05. On the other hand, according to Pearson Theorem, when n is sufficient large (larger than 50), and under null hypothesis we have

$$P_i = P(A_i)(i = 0,1,2,...)$$

The statistical value can be estimated as:

$$T = \sum_{i=0}^{k} \frac{(f_i - np_i)^2}{np_i} \sim \chi^2(k-r) \tag{1}$$

Hence we reject H_0 if $T > \chi^2_{(k-r;\alpha)}$.

Table 1
Result of Poisson distribution test

$N = i$	f_i	$P_i = \frac{0.9696^i}{i!}e^{-0.9696}$	nP_i	$\frac{(f_i - nP_i)^2}{nP_i}$
0	1533	0.3792	1385.3249	15.7421
1	1180	0.3677	1343.2305	19.8359
2	616	0.1783	651.2076	1.9035
3	208	0.0576	210.4733	0.0291
4	84	0.0140	51.0195	21.3196
5	25	0.0027	9.8938	23.0645
6	5	0.0004	1.5989	7.2349
7	1	0.0001	0.2215	2.7368
8	1	0.0000	0.0268	35.2813

Zero-Inflated Poisson Distribution Model

In ZIP model, we suppose N denotes the number of piracy cases in a day. According to the definition of ZIP:

N~ 0	with probability p
N~ Poisson (λ)	with probability 1-p

Where p means the probability of excess zeros and λ represents the expectation of Poisson distribution.

$$P(N = 0) = p + (1-p)e^{-\lambda} \tag{2}$$

$$P(N = k) = (1-p)e^{-\lambda}\lambda^k / k! \tag{3}$$

Maximum likelihood estimation (MLE)

According to Eq. (2) and (3), the likelihood function of the stochastic process in time period of a day can be written as,

$$L(p,\lambda; N_i) = \prod_{i=0}^{n}(p+(1-p)e^{-\lambda}) \times 1_{\{N_i=0\}} \times \prod_{i=0}^{n}(1-p)e^{-\lambda}\lambda^{N_i}/N_i! \times 1_{\{N_i>0\}} \tag{4}$$

$$l = \sum_{i=0}^{n} 1_{\{N_i=0\}} \times \ln[(p+(1-p)e^{-\lambda})] + \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \ln[(1-p)e^{-\lambda}\lambda^{N_i}/N_i!]$$

$$= \sum_{i=0}^{n} 1_{\{N_i=0\}} \times \ln[p+(1-p)e^{-\lambda}] + \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \ln(1-p) - \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \lambda + \sum_{i=0}^{n} 1_{\{N_i>0\}} \times N_i \ln\lambda - \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \ln(N_i!)$$

Taking derivative with p and λ gives,

$$\frac{\partial l}{\partial p} = \sum_{i=0}^{n} 1_{\{N_i=0\}} \times \frac{1-\exp(-\lambda)}{p+(1-p)\times\exp(-\lambda)} - \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \frac{1}{(1-p)} \tag{5}$$

$$\frac{\partial l}{\partial \lambda} = \sum_{i=0}^{n} 1_{\{N_i=0\}} \times \frac{-(1-p)\times\exp(-\lambda)}{p+(1-p)\times\exp(-\lambda)} - \sum_{i=0}^{n} 1_{\{N_i>0\}} + \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \frac{N_i}{\lambda} \tag{6}$$

The first-order necessary and sufficient optimality condition

$$\nabla l(p,\lambda) = 0 \tag{7}$$

yields,

$$\sum_{i=0}^{n} 1_{\{N_i=0\}} \times \frac{1-\exp(-\lambda)}{p+(1-p)\times\exp(-\lambda)} = \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \frac{1}{(1-p)} \tag{8}$$

$$\sum_{i=0}^{n} 1_{\{N_i=0\}} \times \frac{-(1-p)\times\exp(-\lambda)}{p+(1-p)\times\exp(-\lambda)} = \sum_{i=0}^{n} 1_{\{N_i>0\}} \times \frac{\lambda - N_i}{\lambda} \tag{9}$$

Research Highlight 2: Zero-Inflated Poisson Distribution Model of the Occurrence Pattern of Piracy
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Result and Discussion

we calculated the probability mass function of N by two different estimation methods. Then, we plot the probability mass of ZIP (estimated in both methods), and the observed frequency of the random variable in Fig 2.

As for ZIP, the two different estimation methods also affected the fitness. The ZIP estimated by EV matches the observed value better.

Although ZIP models offer improved statistical fit to piracy data, the inherent assumption of a dual state process underlying the development of these models is inconsistent with piracy data. The excess observed zeros arise from the low exposure of piracy accidents. Furthermore, the selection of width of time period influences the number of observed zeros. For example, if the time period is changed to a month, there will be no zero because there are piracy cases in every month.

Conclusion

This study examined the distribution of piracy occurrence based on the piracy data during period 2004 to 2013. It is a new point of view to research into piracy. The result shows that the occurrence of piracy follows Zero-Inflated Poisson distribution. Parameters of the distribution are calibrated by expectation-variance estimation and maximum likelihood estimation. The distribution mass function by maximum likelihood estimation shows to be closer to the values observed than that of mean-variance estimation.

These findings are not only relevant to the authorities engaging in combating piracy but also valuable for insurance companies to understand piracy phenomena better. However, the research is carried out in a global scale. If it is done on a particular location, for example the Malacca Strait, the result would be more valuable to the administrators and industry.
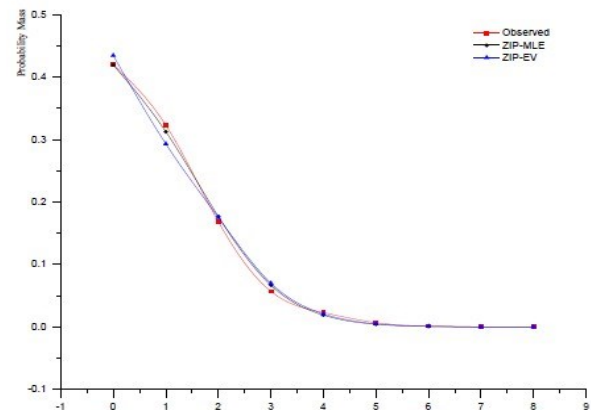
Acknowledgement

Fig. 1. Comparison of Probability mass functions among Observed frequency, ZIP by maximum likelihood estimation, and ZIP by expectation and variance estimation
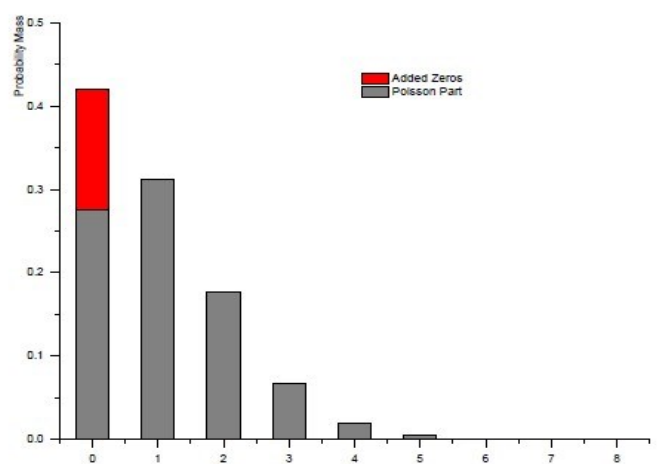

Fig. 2. Added Zeros and Poisson part of ZIP

Published Technical Papers (with Abstracts)

1. Byung Kwon Lee, Loo Hay Lee, Ek Peng Chew, (2014), Analysis on container port capacity: a Markovian modeling approach. *OR spectrum*, Volume 36, Issue 2, pp 425-454

Abstract:

Container ports handle outbound, inbound, and transshipment containers plying between the area for vessels on the quay and the storage space in the yard. Port operators typically concentrate their efforts on the container handling process with the aims of increasing the productivity of quay-side operations and reducing the time in port of vessels. Recognizing that operation processes necessitate containers to stay in the storage space for a certain period before moving to other areas, the operational efficiency at the yard (in addition to that at the quayside) plays an influential role in ensuring performance measures of a container port. This study develops analytical models based on the Markov chain to estimate the port capacity under various combinations of resources, namely, quay cranes, yard cranes, and prime movers. Important performance measures representing the capacity in the proposed models are analyzed and sensitivity analyses of the port capacity are conducted through numerical experiments. The results under the suggested operational strategies are also compared.

2. H Hu, Y Huang, L Zhen, BK Lee, LH Lee, EP Chew, (2014), A decomposition method to analyze the performance of frame bridge based automated container terminal, *Expert Systems with Applications* 41 (2), 357-365

Abstract:

This paper studies a new automated container terminal (ACT) system which utilizes multi-storey frame bridges and rail-mounted trolleys to transport containers between the quay and the yard. Different from widely used AGV–ACT systems, the ACT system studied in this paper uses three types of handling machines, which collaborate to transport containers. This study decomposes the container flow in the new ACT system into three queuing sub-networks. Then an iterative method is developed to analyze the operational efficiency of the ACT system. We analyze its transport efficiency by comparing with the widely used AGV-based systems. This study tries to help port operators better understand the relative merits of this new design and decide whether it is applicable in their terminals.

3. X Jiang, EP Chew, LH Lee, KC Tan, (2014), Short-term space allocation for storage yard management in a transshipment hub port, *OR Spectrum*, 1-23

Abstract:

In transshipment ports, the containers to the same destination vessel are usually stored together to facilitate the loading process, which is called the "consignment". During operation, the actual containers that will come in are only known for a short period in advance. Thus, short-term space allocation is needed to assign incoming containers taking into account the transporting vehicles, yard cranes and storage space. Currently, the space is allocated based on the experience of port operators. To balance the current and future impacts of short-term planning, we develop a systematic method called "space allocation given long-term plan (SALP)". The corresponding MIP model is formulated to utilize not only the short-term information, which includes the existing containers and the actual incoming containers, but also the given long-term plan, which provides a forecast of future requirements. The SALP method is evaluated under two storage strategies to achieve consignment, namely, the "non-sharing strategy" and the "flexible space-sharing strategy". The numerical experiments show that the SALP method improves operational efficiency, but its performance is affected by the portion of long-term plan under consideration.

Published Technical Papers (with Abstracts)

4. Liu, Z., Wang, S. and Meng, Q., (2014), Toll pricing framework under logit-based stochastic user equilibrium constraints, *Journal of Advanced Transportation.* **DOI: 10.1002/atr.1255**

Abstract:

This paper addresses the toll pricing framework for the first-best pricing with logit-based stochastic user equilibrium (SUE) constraints. The first-best pricing is usually known as marginal-cost toll, which can be obtained by solving a traffic assignment problem based on the marginal cost functions. The marginal-cost toll, however, has rarely been implemented in practice, because it requires every specific link on the network to be charged. Thus, it is necessary to search for a substitute of the marginal cost pricing scheme, which can reduce the toll locations but still minimize the total travel time. The toll pricing framework is the set of all the substitute toll patterns of the marginal cost pricing. Assuming the users' route choice behavior following the logit-based SUE principle, this paper has first derived a mathematical expression for the toll pricing framework. Then, by proposing an origin-based variational inequality model for the logit-based SUE problem, another toll pricing framework is built, which avoids path enumeration/storage. Finally, the numerical test shows that many alternative pricing patterns can inherently reduce the charging locations and total toll collected, while achieving the same equilibrium link flow pattern. Copyright © 2013 John Wiley & Sons, Ltd.

5. Liu, Z., and Meng, Q., (2014). Bus-based park-and-ride system: a stochastic model on multimodal network with congestion pricing schemes, *International Journal of Systems Science*, **45(5), 994-1006.**

Abstract:

This paper focuses on modelling the network flow equilibrium problem on a multimodal transport network with bus-based park-and-ride P&R system and congestion pricing charges. The multimodal network has three travel modes: auto mode, transit mode and P&R mode. A continuously distributed value-of-time is assumed to convert toll charges and transit fares to time unit, and the users' route choice behaviour is assumed to follow the probit-based stochastic user equilibrium principle with elastic demand. These two assumptions have caused randomness to the users' generalised travel times on the multimodal network. A comprehensive network framework is first defined for the flow equilibrium problem with consideration of interactions between auto flows and transit bus flows. Then, a fixed-point model with unique solution is proposed for the equilibrium flows, which can be solved by a convergent cost averaging method. Finally, the proposed methodology is tested by a network example.

Conference Papers (with Abstracts)

1. Chu Longjia, T. F. Fwa and H. Nishijima, (2013), Container Port Operational Performance Assessment - A Rational Approach based on Internet Website Port Data. *Proceedings of the 10th Conference of the Eastern Asia Society for Transportation Studies,* **Taipei, Taiwan, 9-12 September 2013.**

Abstract:

With today's rather comprehensive port infrastructure and facilities information made available on public-domain Internet websites by port authorities and operators, it is possible to collect very good quality detailed data and information from such sources alone. This paper presents a case analysis based on 40 major ports in East and Southeast Asia. It demonstrates that good quality port infrastructure and container handling facilities data obtained can be used to derive a statistically significant predictive model of annual port throughputs. The derived information offers meaningful port productivity evaluation and efficiency benchmarking among the 40 ports analyzed. The analysis makes use of the commonly available technique of statistical regression to establish the predicted level of performance. The simplicity of the approach, plus the fact that all required inputs are public domain data obtainable from port websites, permits owners/operators of individual ports or any other users to perform additional analysis if required.

2. Yi Tao, Loo Hay Lee, Ek Peng Chew, (2013), Impact of Information Sharing On Supply Chain Risks. *The International Conference on Logistics and Maritime Systems***, Singapore, 12-14 September, 2013.**

Abstract:

Risks with respect to supply chain have been gathering attention from the researchers recently as industries have faced various supply chain disruptions due to different unforeseen events. In this work, we seek to identify the potential risks and evaluate their impact on the supply chain. Since these risks propagate within the supply chain as well as across other supply chain networks, stakeholders need to work together in mitigating risks and to selectively share information in the process of doing so. We shall investigate what information should be shared among different firms and also evaluate the impact of sharing their private information on supply chain risks.

3. Charles E. Benedict, EP Chew, LH Lee, XJ Jiang, (2013), Grid Frame based Automated Container Terminal. *The International Conference on Logistics and Maritime Systems***, Singapore, 12-14 September, 2013.**

Abstract:

Under the pressure of increasing vessel size, scarcity of the land and tight labor constraint, port authorities are trying to deploy more effective container handling system so as to increase the throughput of the current container terminals without increasing the labor requirement. Automated Container Terminals (ACT) are potential candidates for improving the performance of container terminals. In this paper, we explore a new automated container terminal concept. In this concept, the container terminal is automated with an overhead grid rail structure which covers a wide area of the terminal, directly interfaced with the quay crane, gate buffers and inspection area. The container-handling devices, called Transfer Units (TU), travel on the overhead grid rails and have access to any part of the container yard, thus eliminating the need of ground vehicles. The grid system based ACT stands out in maximizing land utilization, two to three times the storage density of typical port layout, which is a vital advantage in consideration of the scarcity of yard land like Hong Kong and Singapore.

Conference Papers (with Abstracts)

4. Xiaoming Sheng, Loo Hay Lee, Ek Peng Chew, (2013), (s, S) Policy Model for Liner Shipping Refueling and Sailing Speed Optimization Problem. *The International Conference on Logistics and Maritime Systems*, **Singapore, 12-14 September, 2013.**

Abstract:

This work expounds on implementing a dynamic (s, S) policy which has been effectively used in inventory management to solve a liner shipping refueling and vessel speed determination problem under both bunker prices and consumption uncertainties. The stochastic nature of the bunker prices is represented by a scenario tree structure. For the uncertain bunker consumption, we have established in Sheng et al.(2013) that its noise follows a zero mean normal distribution. While solving an optimization model which incorporates a continuous distribution is extremely challenging, if not impossible, we randomly sample sets of scenarios and use Sample Average Approximation (SAA) method to solve it. However, the resulting problem is still a very large scale stochastic mixed-integer programming problem which cannot be solved directly by commercial optimization solvers. Therefore, we propose two variations of the Progressive Hedging Algorithm (PHA) to tackle it. As the problem size becomes even larger, a modified rolling horizon approach will also be adopted. Numerical results show that this combination (SAA, PHA and rolling horizon approach) is efficient and, in addition, our dynamic (s, S) policy model has the potential to be implemented in the real practice easily.

5. Yanhua Xu, Ek Peng Chew, Loo Hay Lee, (2013), Vehicle Dispatching For a New Automated Container Terminal System. *The International Conference on Logistics and Maritime Systems, Singapore,* **12-14 September, 2013.**

Abstract:

This paper considers the problem of scheduling containers under the new designed container terminal called Frame Bridge based Automated Container Terminal (FB-ACT). We address the dispatching problem for frame trolleys in FB-ACT by considering the handshakes among the related resources as well as ensuring conflict-free among the frame trolleys. Our objective is to minimize the makespan. A mixed integer programming (MIP) model is developed to solve the problem. The idea of filter beam search algorithm is borrowed to solve our problem since the existing solver cannot solve the MIP model when the scale of the problem increases. Two distinct evaluation methods are proposed and embedded in the filter beam search algorithm. One is applied in filtering procedure, which is fast in computation; the other method, which is implemented to determine the beam nodes, is more accurate.

6. Xinjia Jiang, Loo Hay Lee, Ek Peng Chew, (2013), Sectioning Strategy for a New Automated Container Terminal System. *The International Conference on Logistics and Maritime Systems, Singapore,* **12-14 September, 2013.**

Abstract:

This study explores a new type of automated container terminal system, which utilizes multi-story frame bridges and railmounted trolleys to transport containers between the quay and the yard. This system is originally designed for a gateway port, where the container handling activities are mainly import or export. For a transshipment hub port, most containers discharged from one vessel will eventually be loaded onto another destination vessel, which challenges the operation mechanism of the automated container terminal system. In order to adapt the system to a transshipment port, a novel storage sectioning idea is proposed in this presentation.

Conference Papers (with Abstracts)

7. Szu Hui Ng, (2013), Bunker management for operational efficiency. *The International Conference on Logistics and Maritime Systems,* **Singapore, 12-14 September, 2013.**

Abstract:

Ocean liner service is the major transportation mode for international trade, and fuel is a major component of operating cost for liner service operators today. In addition, governments and international organizations are developing regulations and guidelines to protect the environment that impose caps on exhausts gas emissions. Consequently, in order to manage operating costs, many operators have implicitly focused on fuel consumption and energy efficiency. In this talk, we will present some recent work on bunker management for shipping liner services, with energy efficiency considerations.

8. Weidong Chen, Thomas Kister, Szu Hui Ng, Loo Hay Lee, and St´ephane Bressan , (2013), Real-time Monitoring of Energy Efficiency and Its Application . *OCOSS 2013 conference, France,* **28-31 October 2013**

Abstract:

The IMO defines the Energy Efficiency Operation Index (EEOI), a static measure for passive monitoring. EEOI does not allow dynamic evaluation of operational strategies. In this article we discuss tools and analytical instruments for the proactive monitoring of energy consumptions and outline the opportunities for planning and operations.

9. Ong, G. P. and Sou, W. S. (2014). An Exploratory Study to Forecast Global Maritime Commodity Trade and Container Demand. *Proceedings of the 93rd Transportation Research Board Annual Meeting,* **12-16 January 2014, Washington D.C., USA.**

Abstract:

Maritime container demand forecasting in the context of international trade is of particular concern to government and policy makers. Numerous efforts have been made in past research to forecast container demand but most of these studies either adopt an economic approach or a transportation perspective. Few studies actually consider the forecasting of maritime container demand from an integrative economic trade-transportation modelling perspective. This paper presents the development of a quantitative demand forecasting approach to predict future seaborne container demand in the global context. Computable general equilibrium models were first developed to derive the amount of trade flow between countries. Through the use of mode choice models and conversion factors derived from trade database, the amount of seaborne trade between countries and consequently, container demand, are obtained. The developed model framework is then applied to study the container demand trends in several countries such as the United States, the European Union, China, Japan, Korea and Southeast Asia between 2008 and 2018. Through this case study, it is found that the model framework is capable to simulate global maritime trade and container demand and could serve as a useful tool for planners in formulating relevant macroeconomic trade and transport policies.

Conference Papers (with Abstracts)

10. Hua Wang, Qiang Meng, Xiaoning Zhang. Park-and-ride network equilibrium with heterogeneous commuters and parking space constraint. *Transportation Research Board 93rd Annual Meeting,* **12-16 January 2014, Washington DC**

Abstract:

This paper first develops the dynamic user equilibrium (DUE) model of heterogeneous commuters' travel choice behaviors including departure time and path/travel mode choices in a schematic park-and-ride (P&R) network. Commuters have three transportation modes - private car, rail transit and the combination of private car and rail transit (i.e., intermodal transportation mode) to choose in a peak period. Two types of DUE patterns are derived with or without the parking space constraint. In this study, an optimal P&R parking fee scheme is proposed, where commuters' travel choice behaviors are characterized by the developed tri-modal multi-class DUE model. The optimal P&R parking fee scheme is formulated as a bi-level program in which the upper level problem is to find the optimal parking fee of improving network performance, and the lower level problem is to evaluate the network performance in equilibrium. In view of the fact that the DUE solution may not be unique, we aim to improve the network performance in the worst and best cases. Through numerical tests, it is demonstrated that parking space constraint has a significant influence on the departure and route choices of commuters, and it should be considered as an important factor in the P&R commuting pattern analysis and the parking fee management in order to avoid misleading decision.

11. Hei, X., Meng, Q., Mao, H., Wang, S., 2014. Optimal automobile distribution model in the multimodal freight transportation networks. *Transportation Research Board 93rd Annual Meeting,* **12-16 January 2014, Washington DC**

Abstract:

This paper first develops the dynamic user equilibrium (DUE) model of heterogeneous commuters' travel choice behaviors including departure time and path/travel mode choices in a schematic park-and-ride (P&R) network. Commuters have three transportation modes - private car, rail transit and the combination of private car and rail transit (i.e., intermodal transportation mode) to choose in a peak period. Two types of DUE patterns are derived with or without the parking space constraint. In this study, an optimal P&R parking fee scheme is proposed, where commuters' travel choice behaviors are characterized by the developed tri-modal multi-class DUE model. The optimal P&R parking fee scheme is formulated as a bi-level program in which the upper level problem is to find the optimal parking fee of improving network performance, and the lower level problem is to evaluate the network performance in equilibrium. In view of the fact that the DUE solution may not be unique, we aim to improve the network performance in the worst and best cases. Through numerical tests, it is demonstrated that parking space constraint has a significant influence on the departure and route choices of commuters, and it should be considered as an important factor in the P&R commuting pattern analysis and the parking fee management in order to avoid misleading decision.

CMS Research Seminars

1. Effect of Trade Data Aggregation on Commodity Mode Choice - A case study in US Transborder Freight Trade, by Researcher Ms. Sou Weng Sut, Maggie (Track Leader: Assistant Prof Raymond Ong)

<u>Seminar Abstract:</u>

Different widely accepted principles in the strategic planning level are used to determine the transport mode in which particular commodity is to be carried. One major rule is the use of commodity value-weight ratio as a means to estimate the amount of goods carried by certain mode. Discrete choice model is being employed in this study using available macroscopic commodity trade information. Besides, the selection of appropriate data aggregation level for analysis is also being investigated and its corresponding impacts are presented. By examining commodity flows between US and Canada, modal split between land, air and sea transport can be compared by the proposed discrete choice models in this study. This study aims to address the potential impact of trade data aggregation on commodity mode choices derived from discrete choice models. Besides, this study also investigate the temporal and spatial transferability of the proposed models.

2. Applications of Game Theoretical and Bi-Level Programing Approach for Maritime Studies, by Researcher Dr. Song Liying (Track Leader: A/Prof Anthony Chin)

<u>Seminar Abstract:</u>

The game between shippers and carriers in an intermodal network is formulated as a Stackelberg game. In this network, shippers make production, consumption, and routing decisions while carriers make pricing and routing decisions. Stackelberg game could be modeled by a bi-level programming model approach.

3. Model of marine propulsion system for efficiency and emission study in ship voyage, by Researcher Dr. Zhao Feiyang (Track Leader: Assistant Prof Yang Wenming)

<u>Seminar Abstract:</u>

Engine is the core propulsion system in transportation industry. But it also brings negative effect due to its emission problem. Many research focus on increasing energy efficiency by advanced engine technology for lower fuel consumption and exhaust emissions, obtaining maximum economy benefits. In this study, a marine engine model is built as the power plant to actuate a container ship. The engine model involves main components of real engine operation and the engine speed is governed by fuzzy-PID controller to overcome the disturbance of propeller load changing due to wave oscillation and course changing in ship voyage. And the fuel consumption and emission could be predicted during engine operation. It helps to explore the potential feasibility of biofuels on shipping.

4. Quantifying and mitigating the impacts of tide on the seaside operations in tidal ports by a collaborative berthing strategy, by Researcher Dr. Du Yuquan (Track Leader: A/Prof Meng Qiang)

<u>Seminar Abstract:</u>

To quantify the impacts of tide on the seaside operations at the operational level, this study models the tidal impacts in the context of berth allocation in a tidal container seaport. Further, this paper proposes a new berthing strategy, which reflects the collaborative scheduling of the port and shipping lines, to mitigate the impacts of tide, and correspondingly retrofit the berth allocation model. Moreover, the state-of-the-art technique of second order cone programming is adopted to handle the nonlinear intractability.

CMS Research Seminars

5. Optimal Contracting in a Buyer-Seller supply chain for an indirect product under price and consumption uncertainty, by Researcher Dr. Giulia Pedrielli (Track Leader: A/Prof Lee Loo Hay)

Seminar Abstract:

Bunker fuel constitutes about three quarters of the operational costs of a liner company. A remarkable effort is then justified both at strategic as well as at operational level, to optimize fuel-related costs.

One fundamental concern for the shipping companies is related to the dramatic variability shaping bunker prices both with respect to time as well as the specific port considered. In this preliminary work, we look into real bunkering contracts to evaluate their effectiveness in protecting both the buyer and the seller against price variability and demand variability. The bunkering with contract problem consists, mainly, in choosing the quantity of fuel on contract and the reservation price. The relevance of the topic is enforced by the lack of contributions in the analysis and optimization of real contracts in the maritime bunkering market especially if both the buyer and the seller are considered. Nonetheless, the contract choices (strategic/tactical level) have a dramatic impact at the operational level. At each port of call, the vessel incurs in bunkering costs which vary based upon the fact that the liner is buying on contract or at spot leading to changes in the adopted bunkering strategy.

Herein, we propose to analyze and optimize the parameters for a real bunker contract, considering simultaneously, the maximization (minimization) of the seller (liner) profit (costs). We propose a game theory based approach and analyze possible model formulations as well as possible games representing the contracting problem. The first numerical evidences will be shown and commented. It is foreseen that the result of this research will be a decision support tool for the players to investigate under which conditions a contract represents an effective tool and, in this case, which strategies to play.

6. Accident Frequency Estimation Model for Ship Navigation in Port Waters, by Visiting Researcher Dr. Wang Hua (Track Leader: A/Prof Meng Qiang)

Seminar Abstract:

This talk will introduce accident frequency estimation models for ship navigation in port waters. We consider three types of ship accidents, namely collision, grounding and contact, and take into account seven types of ships in the port waters. A brief literature review for the accident frequency estimation is provided. By means of the concept of ship domain, we develop three ship domain-based models to estimate the annual accident frequency for three types of accidents.

7. Modeling to Surface Ship Dynamics for Fuel Consumption Estimation: An General Overview, by Visiting Researcher Dr. Yang Jiasheng (Track Leader: A/Prof Tan Woei Wan)

Seminar Abstract:

Modeling of surface ship has become widely used tools in marine engineering, since it is able to effectively predict and improve performances of ship dynamics. Testing ship design and control mechanisms, evaluating ship fuel consumption in the motion, and regulating ship guidance schemes are important applications of ship dynamic modeling. The focus of this talk will be on the general overview of ship dynamic modeling. The seminar concludes with useful information for ship dynamic modeling application.

CMS Research Seminars

8. Dynamic vessel time management and speed optimization in a stochastic weather, by Researcher Dr. Chen Weidong (Track Leader: A/Prof Stephane Bressan)

Seminar Abstract:

We study the operational problem of dynamically determining a vessel's speed, departure time and arrival time at each port of call under dynamic and stochastic weather. We model the minimization of cost, namely bunkering costs and early and delayed departure and arrival penalties, using calculus of variations. We propose an algorithm leveraging the Weierstrass-Erdmann condition. Numerical results show that our solution can provide an accurate numerical solution at lower cost than one obtained with a deterministic model.

9. Zero-Inflated Poisson Model of Global Maritime Piracy Occurrence , by Researcher Mr. Huang Daozheng (Track Leader: A/Prof Meng Qiang)

Seminar Abstract:

The number of piracy cases varies from year to year. It is difficult to predict the number of piracy in a period of time. This paper aims to formulate the occurrence pattern of piracy. In order to formulate the occurrence pattern of piracy, we assume the occurrence process of piracy is a stochastic process and the number of piracy cases in a day is a random variable. To bring the character of the variable to light, the distribution of the variable is fitted. Poisson distribution is the basic model, always regarded as a starting point to formulate count process. Therefore, it is assumed that the occurrence of piracy follows Poisson distribution. However, this hypothesis is rejected by hypothesis test. Through comparison of probability mass function (PMF) of Poisson distribution and observed frequency, we found that there are excess zeros in observed frequency than that of Poisson distribution. Zero-Inflated Poisson (ZIP) is a modified Poisson model defined for count data with excess zeros than general Poisson model. It is hence adopted to model the occurrence of piracy and calculate the PMF of piracy. Then, the parameters of the model are estimated by maximum likelihood estimation and method of moments based on the sample path of piracy data from year 2004 to 2013 collected from the International Maritime Organization's Global Integrated Shipping Information System. Finally, the PMF of the random variable is calculated. Comparing the probability mass of the estimated distribution with the observed frequency of the variable, we found that the maximum likelihood estimation is better than expectation-variance method in this case. It can be used to generate piracy data when simulating maritime safety. The model can also be used to predict the occurrence of piracy in a certain time period.

10. A Physical Perspective on the Global Commodity Trade Flow, By Dr. Farhan Javed (Track Leader: Assistant Prof Raymond Ong)

Seminar Abstract:

During the last few years, there has been extensive research on material flow analysis at a national level. However, empirical studies on material flows in international trade are limited. Global physical trade volume has been increasing over time, and reached more than 19 billion tonnes in 2005. As the trade volume per definition accounts for the sum of both imports and exports, the real trade flow equals half of the reported trade volume. Thus, in 2005 nearly 10 billion - tonnes passed an international border. The dominant traded commodity in physical units was fossil fuels, mainly oil. This presentation describes material flows for dominant resource suppliers and demanders based on the data from United Nations Statistics Division.

CMS Research Seminars

11. Applying the Informational Approach to Global Optimization to the Homoscedastic Stochastic, By Dr. Yuan Jun (Track Leader: A/Prof Ng Szu Hui)

Seminar Abstract:

In many engineering applications, the meta-model serves as a surrogate to the simulation model for global optimization. Previously, the kriging meta-model and the global optimization algorithm, Efficient Global Optimization, are well developed for both the deterministic and the stochastic simulation models with respective versions of the Expected Improvement (EI) criteria. Recently, another global optimization approach, Informational Approach to Global Optimization (IAGO), is introduced for optimizing the deterministic simulation models. This work contributes to refining this approach to solve the stochastic simulation model optimization problem under the homoscedastic intrinsic uncertainty. The comparison between the proposed stochastic IAGO criterion and the Augmented EI (AEI) criterion is conducted with examples. The results show that the proposed stochastic IAGO locates the global optimal point more accurately than the AEI criterion with fewer additional observations required.

12. Evaluation Development in Port Efficiency and Its Application to Port Efficiency System, by Researcher Ms. Song Chunxue(Track Leader: A/Prof Anthony Chin)

Seminar Abstract:

Port efficiency is a crucial indicator of port productivity, port performance and even port competitiveness. Many scholars and researchers endeavored to evaluate ports' efficiency with a variety of indicators and methodologies, within most of which only technical efficiency had been unraveled. As the ever-increasing importance of ports to the global supply chain, could we integrate the port efficiency system and find a new indicators' system to give a relatively holistic evaluation to port efficiency?

13. An Insight into Linking Logistics, Port Efficiency, Trade and Economic Growth , By Researcher Ms. Tea Vizinger (Track Leader: A/Prof Anthony Chin)

Seminar Abstract:

Overall country's performance, its prosperity, efficiency and development abilities are often assimilated with the economic success of a particular state. Most of the recent studies considers only macroeconomic determinants and express them with the gross domestic product as a function of investments, human capital, trade balance, inflation, and even government expenditures. Not only that many determinants affecting overall country's performance are neglected, also particular aspects are explored autonomously instead of considering mutual interactions between them. Corresponding study provides an insight into the determinants affecting overall country's performance. Economic growth on one side and logistical aspects related to port efficiency on the other side are represented as main components, while trading is introduced as an interaction between them. While literature review exposes all the important factors affecting performance of a particular country, further research work is focused on its combination. The final output of the integration approach should correspond to the countries ranking obtained by the estimation of overall score, called as economic and logistics performance index score.

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14. Modelling world shipping demand, by Researcher Mr. Yong Kuan Chen (Track Leader: A/Prof Anthony Chin)

Seminar Abstract:

The world economy undoubtedly is one of the most important components in influencing shipping demand. World economic activity with trade in particular follows a certain pattern. These trade patterns is not easily determined arising from the complexity of business cycles. In turn, business cycles created shipping cycles. Since shipping cycle lies at the heart of shipping risk, investors and ship builders alike are reluctant on determining whether investments should be made on building a new ship. Modern literature is heavily focused on the supply side of shipping where freight rates are more concerned, hence we hope to contribute new literature in this subject as well as to study the causality between important variables in the business cycles and shipping demand.

15. IMO FSA Guidelines and Maritime Risk Assessment – Literature Review and Analysis, by Researcher Dr. He Yaohua (Track Leader: Prof Fwa Tien Fang)

Seminar Abstract:

The Straits of Malacca is one of the most important shipping channels in the world. Current risk assessment focuses on Singapore Straits and Port areas. The coming risk analysis and safety assessment could shift to Malacca Straits beyond Singapore Strait. A literature review on Formal Safety Assessment (FSA) and maritime risk assessment is necessary.

FSA is a structured and systematic methodology for maritime safety using risk analysis and cost-benefit assessment. FSA is continually under review by IMO, not mature yet. Some scholars pointed out some deficiencies in current FSA. Numerous issues are still to be discussed by the FSA expert group. New analysis techniques and indices have been introduced along with the ongoing FSA studies.

Quantitative risk assessment (QRA) is one step of a holistic FSA study. Most existing QRA models are reactive, but not proactive, and some risk control measures are mostly proposed for accident mitigation rather than accident prevention. The static data-driven risk modeling cannot simulate the uncertainty propagation and it is difficult to conduct sensitivity analysis and uncertainty analysis, thus in the cost-benefit analysis step of FSA, the risk reduction cannot be obtained via simulation. An accident can be caused by a series of factors or events which can be classified into situational factors, human errors and vessel failures. These factors should be systematically described and quantified via comprehensive modeling in order to identify the significant factors and root causes.

Bayesian networks (BNs) have been gradually applied to maritime risk assessment. BNs take the advantages to build comprehensive QRA and FSA models for system simulation, sensitivity analysis and uncertainty analysis, overcoming some shortcomings of fault trees, event trees, risk contribution trees and mathematical models. BNs and other first-principle approaches can be used for dynamic assessment. Maritime risk assessment can also borrow the expertise from other industries, such as nuclear power plants and chemical plants, where dynamic risk assessment tools has been developed using near-miss and incident data.

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CMS Research Seminars

16. Optimize Bunker Fuel Management for Shipping Liner Services based on Decomposition , by Researcher Dr. Li Haobin (Track Leader: A/Prof NG Szu Hui)

<u>Seminar Abstract:</u>

The bunker fuel management problem has recently captured much more attention from its stakeholders for both emission controlling and cost saving considerations. In literature, several research works have been conducted to solve the related problems, however, many of them rely on mathematical programming which usually requires a long computation time to be solved. In this work, we analyze the problem by focusing on its optimality conditions, according to which a decomposition-based algorithms can be developed to identify the optimal solution instantly. Rigorous mathematical proofs are provided for each of the optimality conditions concluded; and a web application that implementing the proposed algorithms is developed for numerical experiment and illustration.

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