Application of Fuzzy Delphi-AHP-TOPSIS in Taiwan

Subjects: Geography

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Fuzzy Delphi and FAHP are used to obtain the subjective opinions of carriers and FTOPSIS is used to explore and prioritize the objective opinions of carriers on international crew change ports. This is then used to construct an evaluation model of the key factors influencing the selection of an international crew change location for the development of Taiwanese ports.

Keywords: coronavirus ; crew change ; fuzzy multi-criteria decision-making

1. Introduction

COVID-19 has an unprecedented rate of infection, mortality, and mutation [1]. The double lockdown of closed borders and domestic pandemic-prevention quarantine policies has become the biggest obstacle to ship supply and maintenance operations, international seafarer isolation operations, vaccination, shore leave, crew change, and repatriation operations. With the rise of the pandemic, international crew change has become increasingly strict. The double lockdown set up by each country's epidemic prevention policy has indirectly prevented seafarers from disembarking for crew changes, which in turn has caused seafarers to serve at sea for longer than their established contractual limits. The inability to replace or repatriate seafarers who have been executing their duties for such a long time not only seriously affects the safety and well-being of the crew, but also poses potential concerns for the security of maritime navigation and trade.

With 80% of global trade dependent on maritime transport and nearly 2 million seafarers worldwide needed to operate maritime transport and supply chain systems, Doumbia-Henry [2] in 2020 compiled responses to surveys from governments and the World Health Organization, the International Maritime Organization, the International Labor Organization, and the International Civil Aviation Organization on issues related to ship and airline crew members such as quarantine requirements, border closure restrictions, crew change and repatriation, crew abandonment, certificate and license renewal, and ship supply and inspection. For crew change and repatriation, countries have only pledged to provide necessary assistance, but still with no comprehensive, standardized response.

Approximately 200,000 crew members have been affected by the crew change crisis so far in 2021, although this is down from 400,000 at the height of the pandemic in 2020 [3]. However, with many voyages suspended because of the sharp drop in international trade, the number of cases of crew members not being paid and being forced to stay on board for months without shore leave or being unable to return to their homelands is at a record high. Crews are concerned that, if they are unable to cooperate with the extended working hours and contracts, they may be blacklisted by shipping companies or ship management companies, resulting in unemployment after leaving, which has then, in reality, evolved into forced labor at sea [4].

In a 2020 study on the psychological stress on crew members during the pandemic conducted by Pesel et al. [5], 60% of the crew members cited onboard preventive measures and fear of infection as the main stressors, followed by severe insomnia and a recent sense of unhappiness and frustration in their jobs, indicating that the pandemic has had a significant impact on the crew's state of mind. A study to further understand the depth and breadth of the impact of the pandemic on crew health by Okeleke and Aponjolosun [6] suggests that, over the long term, the lack of a well-designed crew change program will lead to depression, anxiety, and insomnia, which could seriously affect their physical and mental health, as well as navigational safety. To avoid the loss of current crew and problems in recruiting future crew, the assistance of international organizations, national health and pandemic prevention centers, foreign offices, flag states, port state authorities, workers' unions, national medical institutions, and international shipping companies is still needed to provide for and solve the problem of crew change and repatriation. This will effectively reduce the physical and mental health issues and financial problems of the current crew members, as well as ensure the future long-term manpower needs of shipping.

Before the pandemic, the transshipment-research literature was focused on cargo issues, with none related to crew change. After the outbreak of the pandemic, there was clearly a problem with large numbers of international crew members needing to be replaced, and yet few papers began discussing the issues of crew stress and psychological health and none have been conducted concerning the choice of a crew replacement-port location. With the coronavirus constantly evolving, crew vaccination and the crew change crisis remain among the major issues faced by governments worldwide during the pandemic. This research attempts to fill this gap by combining the past standards for cargo transshipment and a Singaporean crew change as the evaluation criteria to try to construct a study on the development of an international crew change port in Taiwan. Taiwan is located where the route between Northeast Asia and Southeast Asia must meet and is also an important cargo transit port for routes from Asia to North America. Combining the strength of Taiwan's epidemic prevention and the establishment of safe and convenient crew transfer centers in seaports and airports, the international maritime reputation from a humanitarian standpoint and attract more shipping companies to call on the ports, increasing port revenues can be increased.

In terms of research methodology, multi-criteria decision-making can be a complete solution to multi-attribute, multi-objective, multi-level, and complex problems for decision makers through a combination of methods. Multi-criteria decision-making refers to making decisions under conflicting standards, since different evaluation criteria may exist under different standards, different characteristics, and different measurement units and relative weights. When the assessment issue involves high investment and high risk, it is very important to frame the problem correctly and clearly evaluate multiple criteria. Among the most commonly used multi-criteria decision-making methods, Delphi, AHP, and TOPSIS are the easiest to understand and implement [7]. However, in real life, human judgment and preferences cannot be accurately given a numerical value, and fuzzy set theory can compensate for this ambiguity and uncertainty.

2. Transit Ports

In terms of transit port risk-related studies, Kengpol et al. [8] conducted an evaluation framework for multimodal route planning from Bangkok to Da Nang looking at freight-damage risks, infrastructure and equipment risks, political and legislative risks, operational risks, macro risks, and environmental risks to reduce intermodal system costs, transport risks, and CO_2 emissions. In terms of selection of the location of transit ports, Chen et al. [9] used eight evaluation components, including location, cost of route, facilities, connectivity, port services, cargo information, customs regulations and government policies, and finance, as well as multiple evaluation criteria such as total cost, facility efficiency, multimodal transport interface, cargo security, safety and reliability, frequency of calling vessels and flights, cargo information availability, stability of government policies, simplicity and transparency of customs procedures, and banking and insurance services, to evaluate the key factors for carriers in selecting transit ports in China.

In an evaluation study of port selection under China's one belt, one road policy, Gao et al. [10] starts with port size, port location, port costs, hinterland economy, operational management, and growth potential as their evaluation framework, based on 18 criteria including container throughput, port infrastructure, industry size, number of working days, inbound and outbound costs, traffic connectivity, customs clearance and government policy, investment trends, and risks for evaluation of the one belt, one road transport as a reference basis for shipping companies in choosing ports of call. Bhatti and Hanjra [11] used port costs, port location, port efficiency, cargo volume, and intermodal connectivity as components and 15 factors including container handling costs, container dwell time, and road, railway line, airport infrastructure, and connectivity to construct the selection criteria for choosing ports of call for the one belt, one road transport mode.

Sumner and Rudan [12] identified the choice of port of call as one of the key factors in the supply-chain system, and therefore complied eight evaluation components through the literature collection, namely transit port, proximity to industry and customs zones, meteo-oceanological factors, proximity to main navigational routes and feeder services, administrative and managerial efficiency, transit port cost structure, and transit port operational efficiency. Among the nearly 50 evaluation criteria, 6 factors, namely backup space at the terminal, transit time, labor problems, state aid and its influence on cost, free time, and port operation and working hours, were not mentioned in the above-cited port-selection literature.

Wang and Yeo [13] argue that total cost, feeder frequency, port staying time, climate, port congestion, availability of the hub port's space allocation, compatibility of cargo information EDI system service, and personal ties with hub port authorities are the main factors for evaluating the key influencing factors in transit from Nanjing to Shanghai and Ningbo via the Yangtze River delta. Kavirathna et al. [14], on the other hand, categorized in a more systematic way the 33 evaluation criteria from the research of Kavirathna et al. [15] into five evaluation criteria, namely monetary, time, location, operation, and liner-related criteria to develop the Bay of Bengal transit port evaluation framework.

3. Outbound Transport

According to Agrawal [16], in addition to the huge losses incurred by the airline industry at this stage because of the suspension of passenger transportation, increased travel restrictions, weak tourism, reduced revenues, cancellation of nonessential business activities, and public fear is expected to cause the passenger transportation demand to fall even further from the current 30% to 60%, which will seriously jeopardize airline operations. Most airlines are unable to withstand the impact of fluctuating oil prices, fluctuating demand, currency devaluation, and the pandemic. If the empty flights of airlines can be chartered to assist international crews to return home, this may help reduce the expected losses from countries closing their borders because of the pandemic.

Since air–sea transportation is not door-to-door, it is necessary to rely on road transport to complete the air–sea transfer, so land transportation between the port and the airport must be considered to assist in crew replacement and repatriation by air–sea transportation. Taiwan's land area is not large but since railroads do not connect with any international airports, they are not able to provide door-to-door service. Therefore, the use of charter buses is recommended to complete the connection between seaport and airport. Alkharabsheh and Duleba [17], in view of the fact that the pandemic has had a serious impact on global transportation, conducted a study on the service quality of road transportation, in which distance between stops, need for transfers, suitable connections, frequency of routes, journey time, and waiting time were used as the criteria.

In view of Vietnam's increasing volume of import and export shipments, logistics centers have become an important logistics infrastructure in the supply chain, and the issue of the siting of logistics centers plays a crucial role in the design and practice of logistics and supply-chain management. Pham et al. [18] combined FDM and TOPSIS to construct a site assessment framework for logistics centers in Vietnam from the standpoint of logistics operators and identified the northeast provinces of Ho Chi Minh, North Hanoi, and Da Nang for the installation of logistics centers in Vietnam in sequential order, according to priority.

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