Journal of ETA Maritime Science 2022;10(1):2-15

# A Fuzzy-Bayesian Approach on the Bankruptcy of Hanjin Shipping

**Muhammet Aydın[1], Bünyamin Kamal[2]**

[1]Recep Tayyip Erdoğan University, Department of Marine Engineering, Rize, Turkey
[2]Recep Tayyip Erdoğan University, Department of Maritime Transportation and Management Engineering, Rize, Turkey

## Abstract

The vital role of container liner shipping in international trade suggests that understanding why container liner firms go bankrupt is crucial to the sustainability of the maritime supply chain to improve resilience. Considering the insolvency of Hanjin Shipping as a case study, this paper investigates the probabilistic relationships among the bankruptcy causal factors that are disclosed qualitatively and quantitatively, exploiting a fuzzy Bayes network approach. A sensitivity analysis is conducted to increase the accuracy of the findings. Outcomes of the paper reveal that an integrated approach comprising of both endogenous and exogenous causal factors is a more powerful approach to explain the demise of Hanjin Shipping. Compared to exogenous factors, endogenous factors account more for the collapse of the firm. Furthermore, it is found that government support would have been a more influential measure to mitigate the negative effects of the demise compared to the merging and acquisition practice. Competitor liner operators, policymakers, and stakeholders in the maritime supply chain ecosystem can utilize the outcomes of this research to mitigate the bankruptcy risk and improve the maritime supply chain resilience capacity.

**Keywords:** Bankruptcy, Causal factors, Liner industry, Hanjin Shipping, Fuzzy Bayes network

## 1. Introduction

There has been a significant increase in global trade, particularly in maritime transportation in the last 30 years [1]. The shipping trade volume increased from 4 billion tons in 1990 to 10.65 billion tons in 2020. A significant part of this trade is carried by container shipping with the volume reaching 152 million twenty-foot equivalent unit (TEU) in 2018 [2,3]. As a dynamic industry, the container shipping industry acts as a key artery of the global economy. However, the weakening global economic outlook harms the operating cash flow of container shipping companies and undermines their balance sheets. Due to the economic impact of the financial recession in 2008, container shipping firms have gone through a cycle of financial challenges with many container liner firms having filed for insolvency [4]. Under this atmosphere, Hanjin Shipping filed bankruptcy protection on August 31, 2016 and was declared bankrupt in February 2017 [5]. The bankruptcy of Hanjin Shipping was the largest the industry has ever witnessed [6], which has worried so many container lines. Given the scope of this container shipping giant's bankruptcy, studies regarding this catastrophic event remain quite a few. The crucial role that container liner shipping plays in international trade suggests that understanding why container ship operators go bankrupt is of vital importance to the stability and sustainability of container liner shipping.

Considering previous studies, a dramatic rise has been observed in the domain of bankruptcy studies, especially since the 2008 financial recession. These studies fundamentally fall within two areas: (1) bankruptcy prediction and (2) business failure processes [7-10]. Similarly, Amankwah-Amoah et al. [11] point out that the last two decades can be regarded as a golden age of bankruptcy studies with a burgeoning research body that considers bankruptcy causes. Some studies in the literature disclosed the causes of dissolved firms. However, despite a burgeoning research body concerning bankruptcy causes, the majority of the studies that have been conducted

**Address for Correspondence:** Muhammet Aydın, Recep Tayyip Erdoğan University, Department of Marine Engineering, Rize, Turkey
**E-mail:** aydinmuham@gmail.com
**ORCID ID:** orcid.org/0000-0002-5478-0909

**Received:** 20.10.2021
**Accepted:** 30.11.2021

**To cite this article:** M. Aydın, and B. Kamal, "A Fuzzy-Bayesian Approach on the Bankruptcy of Hanjin Shipping". *Journal of ETA Maritime Science*, vol. 10(1), pp. 2-15, 2022.

in the maritime transportation domain fall within the scope of bankruptcy prediction [12-15]. Few studies have been carried out that concerns bankruptcy causes, which investigate the bankruptcy of Hanjin Shipping qualitatively. In this context, Pauli and Wolf [16] identified the underlying causes for the liquidation of Hanjin Shipping and analyzed the impact of its bankruptcy from different perspectives such as the South Korean economy, global container liner industry, and actors in Hanjin's immediate proximity. Similarly, Dong-Wook et al. [17] qualitatively revealed the causes that account for why the Hanjin liner firm collapse, and Shin et al. [18] provided bankruptcy reasons briefly, particularly about failed chartering practices. In addition, Li and Dong [4] attempt an analysis on whether China ought to adopt the UNCITRAL Model Law on Cross-Border Insolvency utilizing a strategic game theory approach by taking the Hanjin case into account. A common point in these studies is the qualitative approach of the bankruptcy of the Hanjin firm by solely revealing the failure causes. However, as to the authors' knowledge, no study in the literature has tested the bankruptcy contributory causal factors of a container shipping firm empirically. To evaluate the organization's weak areas and implement mitigating strategies to avoid bankruptcy, it is vital to have an understanding of the amount to which each causal element plays a part in the failure of a container shipping company. Therefore, utilizing these papers [16-18] in terms of failure causes and taking the bankruptcy of the Hanjin firm into account, this paper is a preliminary research that investigates the causal mechanism of a container shipping firm both qualitatively and quantitatively. Further, this paper is an initial research that tests the contributory causal factors for the container shipping firm empirically. Utilizing the Bayesian inference under a fuzzy environment, this paper presents and reveals the probabilistic relationships among the causal factors that led to the bankruptcy of Hanjin Shipping. Results of this research support the body of the literature suggesting that an integrated approach is more powerful to explain the failure causal mechanism than endogenous and exogenous do solely. It is also found that endogenous factors have a more impact in explaining the failure phenomenon than exogenous factors. This study is structured as follows. After introducing the topic, the stages of the Fuzzy-Bayesian approach are explained in section 2. The application of the chosen method, establishment/definitions of variables, and sensitivity analysis are provided in section 3. Results of the established model are discussed and some suggestions were made for the formulation of managerial policies in section 4. Finally, the outcomes are summarized in section 5.

## 2. Methodology

This section provides the details of the Fuzzy-Bayesian network (FBN) approach with the conceptual framework of the methodology shown in Figure 1.

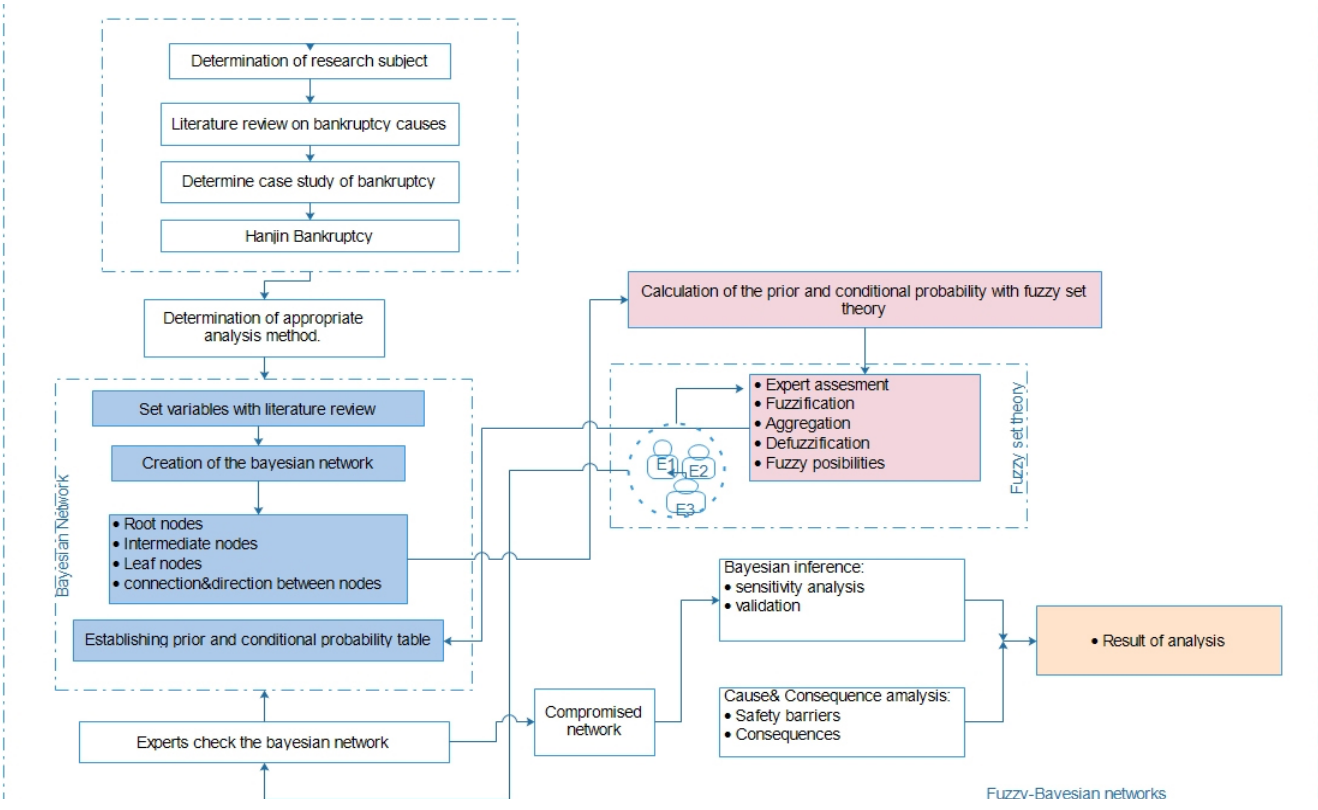


***Figure 1.*** *Research flow chart*

### 2.1. Bayesian Networks (The BN)

The Bayesian Network (BN) approach is gaining increased popularity in the modeling of complex problems that involve probabilistic reasoning. This approach is employed in many different areas including bankruptcy studies [19]. The BN is a flexible and powerful graphical model that discloses the probabilistic relationships between variables [20-22].

The BN approach is also called directed acyclic graph since the relationships between variables are demonstrated on directed acrylic arrows. The graphical representation of the network comprises nodes that display variables, and the directed arrows show the probabilistic causal dependence among the variables. In this illustration, a node in which an arrow originates is called a parent node, while the node to which the arrows are directed is named a child node [23,24].

The quantitative component of the BN manages the probability tables of the variables in the network structure. Probability tables incorporate probabilities, conditional probabilities, and posterior probabilities that are extracted from them. A probability that belongs to the root node is named a marginal probability. Theoretically, the conditional probability table (CPT) and the marginal probability of root nodes could be formulated by incorporating statistical data, expert experience, or a combination of both [25]. The inference principle of the BN approach is based on the Bayes probability theory. In essence, Bayes's theory describes a probability of an event dependent on the prior knowledge of conditions that may be relevant to that event. Algorithms of the inference are given in the following equations [26].

The joint probability distribution of a set of variables $U = \{X_1, X_2 \ldots, X_n\}$ as:

$$P(U) = \prod_{i=1}^{n} P(X_i \setminus P_a(X_i)) \quad (1)$$

where $P_a(X_i)$ is the parent set of variables $X_i$.$X_i$'s marginal probability calculation is as in the following

$$P(X_i) = \sum_{X_j \neq i} P(U) \quad (2)$$

The BN utilizes the Bayes theorem to estimate posterior probabilities of the events, given new observations, named as evidence (E), in the shape of the occurrence of incidents, near-misses, etc., as provided in Equation 3 [27].

$$P(U \setminus E) = \frac{P(U,E)}{P(E)} = \frac{P(U,E)}{\sum_u P(U,E)} \quad (3)$$

### 2.2. FBN

To obtain significant outcomes from the BN structure, assigning the probabilities of the nodes represented in the network is a crucial step. It is pointed out that there are many ways to assign the prior and conditional probabilities of the nodes such as statistical data and literature review. If insufficiency or a high level of uncertainty appears in the statistical data or related literature, the uncertainty can then be eliminated utilizing the fuzzy set theory suggested by Zadeh [28] through employing linguistical values in the evaluation stages. The FBN has been developed to capture the probability values of the nodes in the network structure in the case that statistical data is absent or data is insufficient. Stages of the adopted methodology are shown in the following.

#### *2.2.1. Achieving possibilities from expert judgment*

This research has employed expert evaluation. A heterogeneous expert group has been selected. Each expert has work experience with varying levels in different positions in the agency that served Hanjin Shipping exclusively for several years and was working in the agency at the time when Hanjin was bankrupt. These professionals assess the prior and conditional probability of the nodes on the bankruptcy of Hanjin. In this stage, a weighting process is applied, taking the positions, operational experience, and educational qualifications of the chosen experts into account. To show the differences in the assessment, each professional is assigned different points changing between 0 and 5 [29]. Dependent on Equation (4), the weight scores of the experts are calculated as in the following [30].

$$\text{Weighting factor of expert } (W_\mu) = \frac{\text{Weighting score of the expert}}{\text{Sum of all experts' sweighting scores}} \quad (4)$$

#### *2.2.2. Fuzzification*

Fuzzy numbers portray the ambiguity in the expert evaluation with the membership function that takes values between 0 and 1. Linguistical variables are utilized to describe uncertain statements in natural languages with definite mathematical terms. There are several types of membership functions existing in the literature. Among these, this paper utilizes a triangular fuzzy membership function, which is one of the most employed membership functions [31,32] to capture prior and conditional probabilities of the root and intermediate nodes. Equation (5) presents the membership function for the triangular fuzzy numbers.

$$\mu_{\tilde{A}}(x) = \begin{cases} 0 & x \leq a_1 \\ \frac{(x-a_1)}{(a_2-a_1)}, & a_1 \leq x \leq a_2 \\ \frac{(a_3-x)}{(a_3-a_2)}, & a_2 \leq x \leq a_3 \\ 0, & x \geq a_3 \end{cases} \quad (5)$$

In this research, a linguistic scale comprising seven terms was selected for expert knowledge elicitation to evaluate the probability distribution of the ambiguity of the nodes. Table 1 provides the linguistic scale and the corresponding fuzzy numbers. The abbreviations of the linguistical statements are codified as VVH, VH, H, SH, M, SL, L, VL, and VVL [33,34].

***Table 1.*** *Fuzzy linguistic scale*

| Measurement scale | Triangular fuzzy number | | |
|---|---|---|---|
| | $a_1$ | $a_2$ | $a_3$ |
| VVH | 0.95 | 1 | 1 |
| VH | 0.8 | 0.9 | 0.99 |
| H | 0.65 | 0.8 | 0.95 |
| SH | 0.5 | 0.65 | 0.8 |
| M | 0.35 | 0.5 | 0.65 |
| SL | 0.2 | 0.35 | 0.5 |
| L | 0.05 | 0.2 | 0.35 |
| VL | 0.01 | 0.1 | 0.2 |
| VVL | 0 | 0 | 0.05 |

### *2.2.3. Aggregation of the captured fuzzy possibilities*

Each expert might take different views about the probabilities of events based on their expertise and occupational experience. Because of this, it becomes crucial to achieve a consensus by taking different expert judgments into account. In this regard, combining the assessment of these expert groups, the similarity aggregation method proposed by Hsu and Chen [29] was employed and provided as follows.

$\widetilde{R1}$, $\widetilde{R2}$: A pair of expert opinions,

$S_{UV}(\widetilde{R1}, \widetilde{R2})$: The level of agreement (similarity level) of two different expert judgments,

$S(\widetilde{A}_1, \widetilde{A}_2)$: Degree of similarity between two fuzzy numbers,

$AA(E_u)$: Experts' average agreement

$RA(E_u)$: Relative degree of agreement of experts

CC ($E_u$): Consensus coefficient (CC) degree of the experts

$\widetilde{R}_{AG}$ : The aggregated outcome of the expert decisions.

**Step (1):** The degree of similarity of a pair of experts' judgment is calculated, $S_{UV}(\widetilde{R1}, \widetilde{R2})$ of opinions $\widetilde{R1}$ and $\widetilde{R2}$ of a pair of experts $E_U$ (u=1 to M).

According to this approach, $\widetilde{A}_1=(a_{11}, a_{12}, a_{13})$ and $\widetilde{A}_2=(a_{21}, a_{22}, a_{23})$ are identified as two triangular fuzzy numbers. The similarity degree between the two fuzzy numbers can then be captured by the defined similarity function as in Equation (6).

$$S(\widetilde{A}_1, \widetilde{A}_2) = 1 - (1/4)\sum_{i=1}^{4} | a_{1i} - a_{2i} | \quad (6)$$

**Step (2):** The calculation of average agreement by M experts is as follows:

$$AA(E_u) = \frac{1}{M-1}\sum_{\substack{U\neq V \\ V=1}}^{M} S(\widetilde{A}_1, \widetilde{A}_2) \quad (7)$$

**Step (3):** The degree of relative agreement (RA) is calculated as follows:

$$RA(E_u)\ \frac{AA(E_U)}{\sum_1^M AA(E_U)} \quad (8)$$

**Step (4):** The calculation of the CC of the experts is as follows:

$$CC(E_U) = \beta . w(E_U) + (1-\beta) . RA(E_U) \quad (9)$$

In Equation (9), β takes a value between 0 and 1 and is attributed as the optimism coefficient in the similarity method. In this approach, β (0≤β≤1) is the relaxation factor, which reflects the importance of w ($E_u$) (weight factor of expert u) on RA ($E_u$). When β takes the value of 0, the weight factor of the expert is ignored because there exists a homogenous distribution between the experts. When β takes the value of 1, the expert has the same CC degree and weight significance. The assignment of an appropriate β value is crucial and β takes the value of 0.5 in this research [35].

**Step (5):** Finally, opinions of the experts are aggregated via Equation (10)

$$\widetilde{R}_{AG} = CC(E_1) \times \widetilde{R}_1 + CC(E_2) \times \widetilde{R}_2 + \ldots + CC(E_M) \times \widetilde{R}_M \quad (10)$$

### *2.2.4. Defuzzification*

To make an inference in the Bayesian network, it is required to convert the fuzzy numbers into crisp numbers. Fuzzy prior probabilities and conditional probabilities are transformed into crisp numbers through Equation (12). There exist various approaches for the transformation of fuzzy numbers into crisp numbers in the literature such as the weighted average method, center of sums, centroid method maximum membership degree, and center of the largest area [36]. To minimize loss of knowledge and obtain more correct analysis, this study uses the center of area method owing to its applicability and simplicity [37]. For the transformation of fuzzy numbers into definite numbers, Equation (11) and Equation (12) are provided as in the following.

Defuzzification equation: $X^* = \frac{\int \mu_i(x) dx}{\int \mu_i(x)}$ (11)

For a triangular fuzzy number: $\widetilde{A} = (a_1, a_2, a_3)$

$$X = \frac{\int_{a_1}^{a_2} \frac{x-a_1}{a_2-a_1} x\,dx + \int_{a_2}^{a_3} \frac{a_3-x}{a_3-a_2} x\,dx}{\int_{a_1}^{a_2} \frac{x-a_1}{a_2-a_1} dx + \int_{a_2}^{a_3} \frac{a_3-x}{a_3-a_2} dx} = \frac{1}{3}(a_1 + a_2 + a_3) \quad (12)$$

## 3. Application of the Fuzzy-Bayesian Method on the Bankruptcy of Hanjin

In this section, the FBN method is applied to model the bankruptcy causes for Hanjin Shipping. Before applying this approach, it is important to reveal and define the bankruptcy causes to establish the Bayes network. This study adopts a case study approach to reveal the probabilistic relationships among the failure causes of the Hanjin Shipping firm. Events in real life are investigated via the case study approach that is applied to different areas such as economics, psychology, and political science [38]. Concerning data collection, this paper employs a mixed approach that utilizes both qualitative and quantitative data. It is indicated that this is quite common in the papers adopting case studies [39].

### 3.1. Establishing of Variables for the Hanjin Case

In establishing variables, magazines, brokership reports, and previous studies particularly focusing on the bankruptcy causes of Hanjin have been utilized [16,17]. A network of failure causes for the Hanjin case have been elucidated. In building the causes network, a taxonomy including endogenous and exogenous reasons has been employed [17]. After, industrial expert opinions have been achieved for the verification and updating of the last form of variables and definitions of the conditions of all nodes that will be showing up in the BN. To obtain expert opinions, interviews were conducted through telephone conversations. Before performing the interviews, the experts were briefly informed about the target of this study, the BN method, and the course of disclosing the probabilities. In this stage, eight experts have been contacted. These experts have been working for a long time in different liner companies, including the firm that served Hanjin as an agent, and in different positions such as director, vice general manager, and operation manager. Ultimately, 13 root nodes and 7 intermediate nodes that are thought to be contributors to Hanjin's bankruptcy have been determined. Figure 2 provides the reconciled variables and their relationships among each other.

### 3.2. Identification of Variables

In this paper, causes that led to the bankruptcy of Hanjin were divided into two parts: (1) internal and (2) external. Internal causes have three intermediate nodes: (1) financial flow, (2) commercial management, and (3) ownership management. Meanwhile, external causes have two intermediate nodes: (1) market causes and (2) domestic shipping policies. These intermediate nodes have also root nodes that are illustrated in Figure 2, which will be explained individually below. Furthermore, negative impacts of the bankruptcy on the supply chain of the customers of Hanjin and CKY(H)E alliance are explained as well as government support and merging and acquisition (M&A) as preventative measures.

#### *3.2.1. Internal Causes*

Initial attempts that theoretically investigate the causes why businesses fail can be classified into two large streams. These are voluntaristic and deterministic theories that offer opposing elucidations to the causes of firm failure [40,41]. Internal causes are considered as a voluntaristic perspective, and it is argued that since the main decision-makers are managers/owners, the perceptions and actions of the managers/owners are thus the main reason for the demise. In the context of the bankruptcy of Hanjin, internal causal factors are revealed as follows:

***3.2.1.1. Company governance structure:*** Hanjin Group is one of the biggest chaebols and is a family-controlled conglomerate of the Korean economy that changed its shareholding structure seven times between the years of 2008 and 2014 [42]. The shipping arm of the Hanjin Group was separated as a new entity under Hanjin Shipping Holdings and the chairman of Korean Air, Yang-Ho Cho, was appointed as the new CEO of Hanjin Shipping. In the collapse stage of container shipping markets in 2016, Hanjin Shipping could not receive enough support from Korean Air because of the shareholder structure of Korean Air. The governance structure made Hanjin Shipping vulnerable to overcoming financial challenges [17].

***3.2.1.2. Working capital:*** This attributes to the cause arising from cash flow problems that consequently lead to insufficient working capital. If the freight collection period exceeds the period of payments made to third parties such as terminal operators, bunker suppliers, shipping agents, non-operating containership owners, and Protection and Indemnity Clubs, then this eventually leads to cash flow problems that destabilize the financial situation of the firm. In the case of Hanjin, for instance, it was indicated that the firm owed a combined amount of 182 million dollars to container terminal operators and stevedores and 67 million dollars to container leasing companies [43].

***3.2.1.3. Issuing bonds:*** Hanjin Shipping issued corporate bonds to raise capital since after the 2008 financial crisis, banks as traditional financiers of the shipping industry became prudent to provide capital to the industry. The

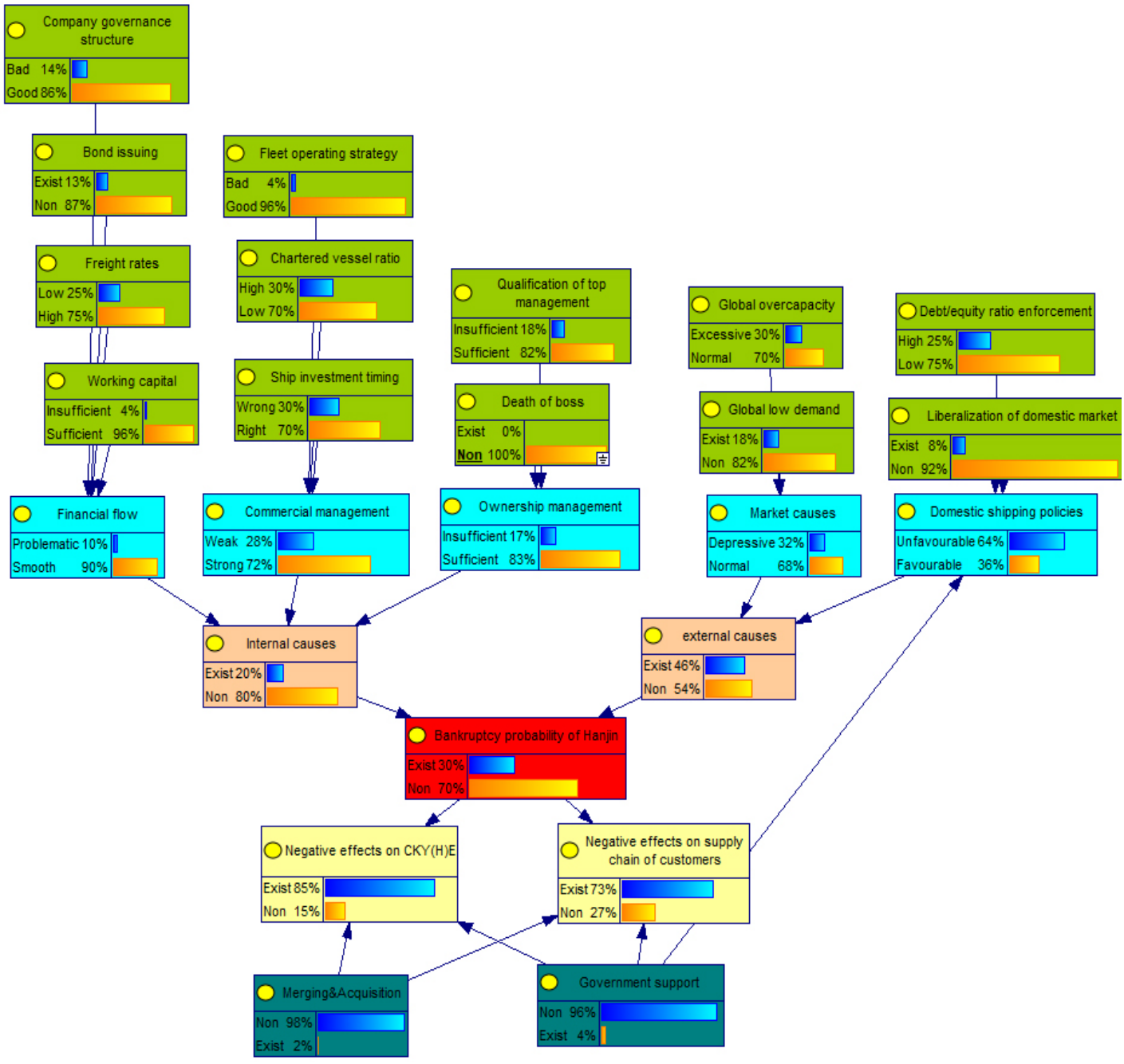


***Figure 2.*** *Modeling of the causes of the bankruptcy of Hanjin under the FBN approach*

*FBN: Fuzzy-Bayesian network*

face value of the issued corporate bonds reached KRW 700 million on average between 2009 and 2012. Issuing bonds can be regarded as a fast way to obtain capital. However, one disadvantage of it is that compared to bank loans, bonds often have shorter maturity periods. As a reflection of this, it is indicated that most of Hanjin's bonds in 2015 had only two years of maturity and its bonds which would mature within the following three years, had a total value of about KRW 1.4 trillion [16,17].

***3.2.1.4. Freight rates:*** In a depressed stage of a shipping cycle with a sharp decrease in demand, the gap between supply and demand widens significantly leading to a deepening overcapacity in the sector. This increased overcapacity resulted in the reduction of freight rates [32]. In this regard, Dong-Wook et al. [17] pointed out that Hanjin declared general rate increases many times. However, it was not satisfactory because of depressive market conditions.

***3.2.1.5. Qualification of top management:*** One of the reasons that contribute to the bankruptcy of Hanjin can be attributed to the insufficiency of the top management. This phenomenon can be explained to some extent by the fact that Hanjin Shipping is part of a chaebol. Chaebols are operated by family members and generally, the top management is chosen by family members even though family members do not have enough qualifications and industry knowledge. In the case of Hanjin Shipping, after Soo-Ho Cho, a son of the founder, passed away, his wife, Eun-Young Choi, managed the firm between 2006 and 2014. It is pointed out that she had no distinctive management experience and she acknowledged her partial responsibility in the bankruptcy of the firm [16].

***3.2.1.6. Personal life of owner:*** Reasons stemming from an owner's personal life such as death, marriage, divorce, and illness can affect the operations of a company. In the case of Hanjin, group firms were divided into four sons after the death of the founder, which resulted in disputes among siblings and weakening relationships with group firms for surviving on their own [17].

***3.2.1.7. Chartered vessel ratio:*** Carrying a high level of chartered vessels compared to owned vessels results in increased operational costs and decreased profits under depressive market conditions. For instance, Hanjin's charter rates with Seaspan, a non-operating container vessel owner, cost USD 43,000 per day when rates of a spot charter were about USD 25,000 per day [16]. This was the phenomenon that Korean container liner firms experienced negatively due to the debt-equity ratio enforcement of the Korean government. For example, the chartered to owned fleet ratio was about 60% in the container liner industry. This ratio increased to 80% in Hanjin Shipping in 2010 [44].

***3.2.1.8. Ship investment timing:*** It was claimed that several vessel chartering contracts made by Hanjin Shipping were 2 or 3 times more expensive than the average market level just before the collapse stage of the shipping cycle in 2008. The worse one indicates that such chartering fee is about five times higher than the average market price after the 2008 financial recession [16]. This phenomenon can be explained to some extent with the chartering managerial shift. Due to the death of the company's chief executive officer, the ownership was changed in 2007. Several top executives with extensive and long-term chartering experience resigned from the company during the period of the top management transition [18].

***3.2.1.9. Fleet operating strategy:*** To sustain profitability under depressive market conditions, container liner firms are required to take new initiatives. In this way, some mega container firms entered into North-South trade routes containing developed and emerging economies, e.g., Africa and South America, as a niche market. However, Hanjin continued to focus on routes where it showed a strong presence such as the Transpacific route and failed to expand service coverage to niche markets [16].

### 3.2.2. External Causes

The deterministic perspective argues that managers are restricted by external environmental/industrial constraints that leave them with a real strategic option and therefore, the role of the owners/managers should be ignored. In this approach, external causes are regarded as contributory reasons that consequently lead to bankruptcy, and in the context of the failure of Hanjin, external factors are revealed as follows:

***3.2.2.1. Global low demand:*** It is observed that container shipping experienced the collapse stage of a shipping cycle severely due to decreasing demand especially after the second half of 2015 [45]. No remarkable improvement was observed in markets in the first half of 2016 and China's containerized freight index dropped to a 632-point level in April 2016, which is the lowest level since its inception in 1998 [46].

***3.2.2.2. Global overcapacity:*** Container liner markets have been struggling with overcapacity particularly since the 2008 financial crisis. The opening of the new Panama Canal also worsened the overcapacity plaguing the industry. Due to the opening of new locks of the Panama Canal, some 3,000-5,000 TEU container vessels became less attractive in trade [46]. As a result, the increased surplus capacity left operators with overcapacity reduction options.

***3.2.2.3. Debt-equity ratio enforcement:*** One of the causes of Hanjin's bankruptcy was attributed to the debt-equity ratio regulation initiated by the Korean government, which does not suit well to the container liner industry. For example, the Korean government asked a debt-to-equity ratio of less than 200% in 1998-1999 regardless of the industry type. As a result, liner firms of Korea had to sell some of their vessels to reach that ratio [17]. Similarly, to obtain support from the government-led shipping/shipbuilding fund, it was required to lower the debt-to-equity ratio to 400% in 2016. However, Hanjin Shipping was able to reduce this ratio to 600% by June 2016. Due to this, Hanjin Shipping could not receive support from the specified fund [16].

***3.2.2.4. Liberalization of domestic market:*** Some practices are used to work in favor of domestic shipping firms such as the business license system, cargo waiver system, and cargo reservation system. These applications protected domestic carriers, restricted new entrants to the maritime industry, and also gave priority to Korean-flagged vessels to transport cargoes [47,48]. However, as a reflection of deregulation and liberalization policies that were introduced in the late 1980s,

the cargo waiver system was repealed in 1995, the license system for shipping routes was changed in 1996, and the reservation system was repealed in 1999. Deregulation and liberalization policies left Hanjin in a cut-throat competition in the domestic market [17].

***3.2.2.5. Government support:*** In today's globalized world, some countries approach the own liner industry as a key strategic industry and tend to support their shipping lines especially [49]. In this regard, for instance, the Danish government provided a loan of 6.2 billion USD for Maersk in 2011. However, Hanjin could not receive financial support from the Korean government in 2016 [17]. Also, Yang-ho Cho, which is the head of Hanjin Group, the parent company of Hanjin Shipping, claimed that their shipping branch had not competed on equal terms with their rival container lines because the majority of them had obtained the support of their governments [50].

***3.2.2.6. M&A:*** The bankruptcy of Hanjin has caused the acceleration of the M&A process in the liner industry to obtain enough market share and increase operational efficiency concerning the concept of a size-related scale of the economy [51]. In this regard, for instance, Cosco merged with OOCL and Hapag-Lloyd merged with United Arab Shipping Company [52,53].

***3.2.2.7. Negative impacts on the supply chain of customers:*** The bankruptcy of Hanjin had a ripple effect throughout the customers' supply chain. A sizable amount of customers whom Hanjin used to serve can be considered as time-sensitive customers since they agreed to pay a high freight rate in exchange for the fast delivery service of Hanjin. However, some customers operating in the clothing industry missed the fashion season and some could not even receive their cargo. Because of the disruptions, customers became cautious in their dealings with container lines [52].

***3.2.2.8. Negative impacts on CKY(H)E alliance:*** Carriers share slots under highly-structured strategic alliances and Hanjin had been involved in the CKY(H)E alliance before bankruptcy. Not only shippers but also Hanjin's alliance partners, Cosco, Evergreen, Yang Ming, and K-Line, scrambled to determine what would occur to their cargo on board Hanjin vessels. As a CKY(H)E partner, the K-Line was the most exposed, with container boxes on 63 Hanjin vessels [54].

### 3.3. Establishing Prior and CPTs

Prior probabilities and CPTs were created for each node existing in the BN after establishing the BN graphical structure and designating the condition of the nodes. To perform this, an excel file that includes the definitions of the bankruptcy causes, conditions of the nodes, and questions to reveal the probabilities was delivered to the experts. The fuzzy linguistic scale was exploited as given in Table 1. In this stage, an assessment of the probabilities between node relations was obtained from three experts. Since the qualification of professionals is considered different, a weighting process is necessary to reveal their differences in the assessment process. Therefore, the occupational position, work experience, and level of education as weighting criteria are taken into account, and each variable is assigned a value ranging from 0 to 5.

Table 2 provides the details that are considered for the weighting values of the experts, while Table 3 shows the details for the experts and calculations of the weighting process [35].

The GeNle version 2.2.1 software was used to utilize the data in BN modeling. Before exploiting the GeNIe program, expert judgments that are achieved on the ground of linguistic expression were fuzzified through triangular fuzzy members. Following that operation, a similarity aggregation method that is developed by Hsu and Chen [29] was used to reach a compromise about expert opinions. Since expert opinions were obtained on a fuzzy scale, it is required to transform them into crisp numbers through the defuzzification process by employing the center of area approach as provided in equations 10 and 11. All these transactions were conducted in an MS Office Excel file so that the data would be prepared for proceeding with the GeNle software. Experts provided fuzzy conditional probabilities for intermediate and leaf nodes. Because of limited space, just a part of a CPT of the commercial management node is provided in Table 4.

***Table 2.*** *Criteria for weighting*

| Constitution | Classification | Score |
|---|---|---|
| Professional position | Director | 5 |
| | Operation manager | 4 |
| | Logistics manager | 3 |
| | Regional manager | 2 |
| | Territory sale executive | 1 |
| Occupational experince | More than 15 years | 5 |
| | 11 to 15 | 4 |
| | 6 to 10 | 3 |
| | 3 to 5 | 2 |
| | Less than 3 years | 1 |
| Educational level | PhD | 5 |
| | Master | 4 |
| | Bachelor | 3 |
| | HND | 2 |
| | School level | 1 |
| HND: Higher National Diploma | | |

***Table 3.*** *Details of experts and calculations of weighting scores*

| Expert Level | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Expert no** | **Professional position** | **Experience** | **Education level** | **Weighting factor** | | | **Tw** | **Weighting score** |
| 1 | Operation Manager | 24 | Bsc | 4 | 5 | 3 | 12 | 0.3428 |
| 2 | Logistics Manager | 17 | Bsc | 3 | 5 | 3 | 11 | 0.3142 |
| 3 | Director | 15 | Bsc | 5 | 4 | 3 | 12 | 0.3428 |

***Table 4.*** *Table of conditional probabilities for the commercial management intermediate node*

| **Chartered vessel ratio** | **High** | | | | **Low** | | | |
|---|---|---|---|---|---|---|---|---|
| **Ship investment timing** | **Wrong** | | **Right** | | **Wrong** | | **Right** | |
| Fleet operating strategy | Bad | Good | Bad | Good | Bad | Good | Bad | Good |
| Weak | 0.986 | 0.969 | 0.336 | 0.183 | 0.816 | 0.663 | 0.031 | 0.014 |
| Strong | 0.014 | 0.031 | 0.664 | 0.817 | 0.184 | 0.337 | 0.969 | 0.986 |

### 3.4. Sensitivity Analysis

The sensitivity analysis is of vital importance in the probabilistic assessment. The effect of the precautions taken to hinder the undesired event is revealed via the sensitivity analysis, and variables are ranked on the ground of their effects on the target node [55]. A sensitivity analysis was conducted for all nodes, and the outcomes are shown in Table 5. Based on the sensitivity analysis, after internal causes and external causes, the commercial management, ownership management, ship investment timing, and qualification of the top management are the major contributing variables that account for the bankruptcy of Hanjin. After, sensitivity analyses for all child-parent node combinations were carried out. Only the financial flow and commercial management causes sections were incorporated as in Table 6.

Furthermore, sensitivity analyses are performed to evaluate the bankruptcy of Hanjin in terms of the negative effects on the CKY(H)E alliance and the supply chain of customers in connection to the prevention barriers that are M&A and support of government measures (Table 7).

## 4. Findings and Discussion

In this research, a cause-consequence approach was conducted for the bankruptcy of the Hanjin case under the FBN method. Variables are established based on the literature review and confirmed by experts. The probability of the bankruptcy of Hanjin was calculated as 30% by utilizing the BN (Figure 2). It is revealed that this ratio increases to 97% when internal and external causal factors exist together (Figure 3). Findings of this paper support the literature body suggesting that an integrative approach is a more powerful way of explaining the causal mechanism of bankruptcy than internal and external do solely [56-58].

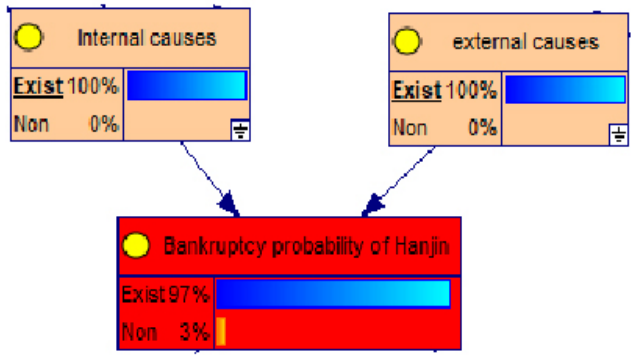


***Figure 3.*** *Conditional probabilities for the bankruptcy of the Hanjin node*

According to Hall [59], Gaskill et al. [60], and Arditi et al. [61], internal causes were the most frequent causes that account for firm failure. Whereas, Baldwin et al. [62] point out that internal and external causes carry equal importance in explaining the bankruptcy of a firm. Taking the sensitivity analysis results into account, it is observed that internal causes have the largest impact on the occurrence of the bankruptcy of Hanjin. As provided in Table 5, the variation of the leaf node (bankruptcy of Hanjin) occurrence probability in the network is 62%. Thus, it is revealed that the outcomes of this study are in parallel with the studies of Hall [59], Gaskill et al. [60], and Arditi et al. [61]. Internal causes are followed by weak commercial management, which has the second strongest effect on the occurrence of the bankruptcy of Hanjin with a variation of the leaf node (bankruptcy of Hanjin) occurrence probability in the network of 32.9%.

Based on the sensitivity analysis, after internal causes and weak commercial management, the external causes, wrong timing of ship investment, and insufficient ownership management are the major contributing variables that

***Table 5.*** *Sensitivity analysis for all nodes*

| Nodes | Condition 1st | Prior % | Change node state 1 100% | Change node state 2 100% | Bankruptcy prior probability | Bankruptcy posterior probability state 1 100% | Bankruptcy posterior probability state 2 100% | Change of probability |
|---|---|---|---|---|---|---|---|---|
| Company governance structure | Bad | 0.140 | 100 | 100 | 0.305 | 0.337 | 0.299 | 0.038 |
| Bond issuing | Exist | 0.134 | 100 | 100 | 0.305 | 0.317 | 0.303 | 0.014 |
| Freight rates | Low | 0.249 | 100 | 100 | 0.305 | 0.317 | 0.3 | 0.017 |
| Working capital | Insufficient | 0.044 | 100 | 100 | 0.305 | 0.325 | 0.304 | 0.021 |
| Fleet operating strategy | Bad | 0.044 | 100 | 100 | 0.305 | 0.328 | 0.304 | 0.024 |
| Chartered vessel ratio | High | 0.303 | 100 | 100 | 0.305 | 0.353 | 0.284 | 0.069 |
| Ship investment timing | Wrong | 0.301 | 100 | 100 | 0.305 | 0.464 | 0.236 | 0.228 |
| Qualification of top management | Insufficient | 0.179 | 100 | 100 | 0.305 | 0.384 | 0.287 | 0.097 |
| Death of boss | Exist | 0.168 | 100 | 100 | 0.305 | 0.344 | 0.297 | 0.047 |
| Global overcapacity | Excessive | 0.301 | 100 | 100 | 0.305 | 0.398 | 0.265 | 0.133 |
| Global low demand | Exist | 0.179 | 100 | 100 | 0.305 | 0.312 | 0.303 | 0.009 |
| Debt/Equity ratio enforcement | High | 0.247 | 100 | 10 | 0.305 | 0.339 | 0.294 | 0.045 |
| Liberalization of domestic market | Exist | 0.076 | 100 | 100 | 0.305 | 0.325 | 0.303 | 0.022 |
| M&A | Non | 0.983 | 100 | 100 | 0.305 | 0.305 | 0.305 | 0.000 |
| Government support | Non | 0.956 | 100 | 100 | 0.305 | 0.308 | 0.237 | 0.071 |
| Financial flow | Problematic | 0.096 | 100 | 100 | 0.305 | 0.403 | 0.294 | 0.109 |
| Commercial management | Weak | 0.276 | 100 | 100 | 0.305 | 0.543 | 0.214 | 0.329 |
| Ownership management | Insufficient | 0.218 | 100 | 100 | 0.305 | 0.434 | 0.269 | 0.165 |
| Market causes | Depressive | 0.316 | 100 | 100 | 0.305 | 0.413 | 0.255 | 0.158 |
| Domestic shipping policies | Unfavorable | 0.644 | 100 | 100 | 0.305 | 0.346 | 0.231 | 0.115 |
| Internal causes | Exist | 0.209 | 100 | 100 | 0.305 | 0.801 | 0.174 | 0.627 |
| External causes | Exist | 0.458 | 100 | 100 | 0.305 | 0.469 | 0.166 | 0.303 |
| M&A: Merging and acquisition | | | | | | | | |

***Table 6.*** *Sensitivity analysis for the financial flow cause & commercial management causes*

| Child node | Parent nodes | Condition 1st | Prior % | Change node state 1 100% | Change node state 2 100% | Financial flow prior probability | Financial flow posterior probability state 1 100% | Financial flow posterior probability state 2 100% | Change of probability |
|---|---|---|---|---|---|---|---|---|---|
| Financial flow | Company governance structure | Bad | 0.140 | 100 | 100 | 0.096 | 0.392 | 0.047 | 0.345 |
| | Bond issuing | Exist | 0.134 | 100 | 100 | 0.096 | 0.212 | 0.078 | 0.134 |
| | Freight rates | Low | 0.249 | 100 | 100 | 0.096 | 0.214 | 0.057 | 0.157 |
| | Working capital | Insufficient | 0.044 | 100 | 100 | 0.096 | 0.282 | 0.087 | 0.195 |
| Commercial management causes | Fleet operating strategy | Bad | 0.044 | 100 | 100 | 0.276 | 0.347 | 0.273 | 0.074 |
| | Chartered vessel ratio | High | 0.303 | 100 | 100 | 0.276 | 0.424 | 0.212 | 0.212 |
| | Ship investment timing | Wrong | 0.301 | 100 | 100 | 0.276 | 0.761 | 0.068 | 0.693 |

***Table 7.*** *Consequence analysis for the negative impact on the alliance*

| Child node | Parent nodes | Condition 1st | Prior % | Change node state 1 100% | Change node state 2 100% | Negative effects on CKY(H)E prior probability | Negative effects on CKY(H)E posterior probability state 1 100% | Negative effects on CKY(H)E posterior probability state 2 100% | Change of probability |
|---|---|---|---|---|---|---|---|---|---|
| Negative impact on alliance | Bankruptcy | Exist | 0.305 | 100 | 100 | 0.847 | 0.948 | 0.803 | 0.145 |
| | M&A | Non | 0.017 | 100 | 100 | 0.847 | 0.854 | 0.463 | 0.391 |
| | Government support | Non | 0.044 | 100 | 100 | 0.847 | 0.871 | 0.347 | 0.524 |
| Negative impact on the supply chain of customers | Bankruptcy | Exist | 0.305 | 100 | 100 | 0.734 | 0.985 | 0.624 | 0.361 |
| | M&A | Non | 0.017 | 100 | 100 | 0.734 | 0.741 | 0.344 | 0.397 |
| | Government support | Non | 0.044 | 100 | 100 | 0.734 | 0.754 | 0.294 | 0.460 |
| M&A: Merging and acquisition | | | | | | | | | |

account for the bankruptcy of Hanjin. External causes lead to a 30% variation on the occurrence probability of the bankruptcy of Hanjin, which was followed by wrong ship investment timing, which has the highest impact on the explanation of the commercial causes with a 69% variation impact on the occurrence probability of commercial management causes (Table 6). Outcomes of this paper are in line with Shin et al. [18] as it is indicated that chartering contract management featuring a long period and chartering of mega-container vessels over 10,000 TEU rather than owning was regarded as the major causes for Hanjin's demise. To mitigate the effects of the weak commercial management and specifically wrong ship investment timing, container liner firms should establish an effective chartering policy that implies a lessening of the chartering period and decreasing of the ratio of chartered mega-container vessels in the fleet composition, since these pose a greater risk under depressive market conditions that Hanjin had experienced. Wrong ship investment timing is followed by insufficient ownership management with the node exhibiting a 16% variation on the occurrence probability of the bankruptcy of Hanjin. To mitigate the effects of the causal factors of insufficient ownership management, it is recommended that liner firms should set up an effective succession planning policy that identifies and prepares potential candidates for high-level managerial positions that become unoccupied because of death, resignation, retirement, etc. In the case of Hanjin, the ownership was changed due to the passing of the CEO in 2007, and various high-level managers having a long period of chartering experience resigned from the firm in the stage of transition of the top management. As a result, this undermined the Hanjin's capability to maneuver in the depressive market environment [16].

Elaborating on the financial flow causes, the bad company governance structure has the largest effect on the occurrence of the problematic financial flow since this node leads to a 34% variation on the occurrence probability of the financial flow factor (Table 6). This is followed by insufficient working capital. Low freight rates have the least impact on the occurrence probability of the problematic financial flow (Table 6).

Furthermore, the bankruptcy of Hanjin is found to have a significant negative impact on the CKY(H)E alliance and the supply chain of customers of 85% and 73%, respectively. If the occurrence of the bankruptcy of Hanjin is realized, the negative impact on the CKY(H)E alliance is then increased from 85% to 94.8%. Similarly, this ratio is increased from 73% to 98.5% for the negative effects on the supply chain of customers. Based on this, it can be inferred that the impact of the bankruptcy of Hanjin on the supply chain of customers is higher than that of the alliance. After Hanjin's bankruptcy, carrier financial stability has been a very important issue for the supply chains. After, the consequences of Hanjin bankruptcy are evaluated and associated with prevention barriers (M&A and government support) that aimed to prevent Hanjin from bankruptcy. If the M&A activity had been performed, negative effects on the CKY(H)E alliance could have been reduced from 85% to 46%. Similarly, if the South Korean government had supported Hanjin, then the negative effects on the CKY(H)E alliance could have been reduced from 85% to 35%. Therefore, it can be inferred that government support could have been a more influential measure to mitigate the negative effects on the CKY(H)E alliance. On the other hand, if the M&A measure had been taken, then the negative effects on the supply chain of customers could have been decreased from 73% to

34%. Similarly, if Hanjin had been supported by the Korean government, the negative effects on the supply chain of customers could have been decreased from 73% to 29%. Thus, it can be deduced that government support could have been a more effective measure to mitigate the negative effects on the supply chain of customers.

## 5. Conclusion

This study uniquely presents the probabilistic relationships among the causes that led to the bankruptcy of Hanjin and contributes significantly to the bankruptcy causes literature through handling a case study approach utilizing the Fuzzy-BN approach. It is found that an integrative approach is a stronger way to explain the bankruptcy event. Compared to the deterministic approach, the results of this research favor the voluntaristic perspective. Furthermore, it is revealed that weak commercial management, external causes, and wrong ship investment timing are found as the major contributing variables for bankruptcy. As a preventative measure, government support is revealed to be a more influential measure to mitigate the negative effects on the CKY(H)E alliance and supply chain of customers compared to the M&A initiative. In this regard, the findings of this research are considered to provide useful insight for container shipping stakeholders as they can be assisted to better understand the bankruptcy causal mechanism and to differentiate their efforts to mitigate the failure risk. In this research, the bankruptcy of Hanjin is considered as a static event and in a further study, external and internal causes can be examined as a dynamic process.

### Authorship Contributions

Concept design: M. Aydın, B. Kamal, Data Collection or Processing: B. Kamal, Analysis or Interpretation: M. Aydın, B. Kamal, Literature Review: B. Kamal, Writing, Reviewing and Editing: M. Aydın, B. Kamal.

**Funding:** The author(s) received no financial support for the research, authorship, and/or publication of this article.

## REFERENCES

[1] A. Ergin, and M. F. Ergin. "The role of antifouling coating in the marine industry." *Research & Reviews in Engineering,* 53.

[2] Review of Maritime Transport, 2020.

[3] Review of Maritime Transport, 2021.

[4] Z. Li and B. Dong. "A Game Theory Analysis of China's Maritime Cross-Border Insolvency Policy: From the Perspective of Hanjin Shipping's Bankruptcy Case." *Maritime Policy and Management,* vol. 48, pp. 419-31, Jun 2020. https://doi.org/10.1080/03088839.2020.1779366.

[5] "Hanjin: Final Curtain Falls On Shipping Saga". 2021. BBC News. https://www.bbc.com/news/business-38953144.

[6] "Global Trade Review". Nov/Dec 2016. https://fhr.rapidratings.com/hubfs/Global%20Trade%20Review.pdf?t=1481914337944.

[7] J. Sheppard, and S. D. Chowdhury. "Riding the wrong wave: organizational failure as a failed turnaround." *Long Range Planning,* vol. 38, pp. 239-60, June 2005.

[8] H. Ooghe, and S. D. Prijcker. "Failure processes and causes of company bankruptcy: a typology." *Management Decision,* vol. 46 pp. 223-42, March 2008.

[9] M. Eling, and R. Jia. "Business failure, efficiency, and volatility: evidence from the European insurance industry" *International Review of Financial Analysis,* vol. 59, pp. 58-76, Oct 2018.

[10] Y. Shi, and X. Li. "An overview of bankruptcy prediction models for corporate firms: a systematic literature review." *Intangible Capital,* vol. 15, pp. 114-27, Oct 2019.

[11] J. Amankwah-Amoah, R. E. Hinson, B. Honyenuga, and Y. Lu. "Accounting for the transitions after entrepreneurial business failure: an emerging market perspective" *Structural Change and Economic Dynamics,* vol. 50 pp. 148-58, Sep 2019.

[12] C. Th. Grammenos, N. K. Nomikos, and N. C. Papapostolou. "Estimating the probability of default for shipping high yield bond issues." *Transportation Research Part E: Logistics and Transportation Review*, vol. 44, pp. 1123-38, Nov 2008.

[13] R. Adland, and H. Jia. "Charter market default risk: a conceptual approach" *Transportation Research Part E: Logistics And Transportation Review,* vol. 44, pp. 152-63, Jan 2008.

[14] H. Yeo, "Solvency and liquidity in shipping companies." *Asian Journal of Shipping and Logistics,* vol. 32, pp. 235-41, Dec 2016.

[15] J. Haider, Z. Ou, and S. Pettit. "Predicting corporate failure for listed shipping companies." *Maritime Economics and Logistics*, vol. 21 pp. 415-38, Feb 2018.

[16] J. Pauli and M. Wolf. 2017. "Hanjin Shipping : Slow-Steaming into Bankruptcy Causes and Effects." https://gupea.ub.gu.se/bitstream/2077/52799/1/gupea_2077_52799_1.pdf.

[17] S. Dong-Wook, S. Young Joon, and K. Dong-Wook. "Learning from Hanjin Shipping's failure: A holistic interpretation on its causes and reasons." *Transport Policy,* vol. 82 pp. 77-87, Oct 2019.

[18] S.H. Shin, P. Tae-Woo Lee, and S.W. Lee. "Lessons from bankruptcy of Hanjin Shipping Company in chartering." *Maritime Policy and Management,* vol. 46, pp. 136-55, Feb 2019.

[19] N. Kalyan, and A. Sridhar. "A predictive system for detection of bankruptcy using machine learning techniques." *International Journal of Data Mining & Knowledge Management Process* vol. 5, pp. 29-40, Feb 2015.

[20] M. Aydin, S. S. Arici, E. Akyuz, and O. Arslan, "A probabilistic risk assessment for asphyxiation during gas inerting process in chemical tanker ship." *Process Safety and Environmental Protection*, vol. 155. pp. 532-542, Nov 2021.

[21] E. Cakir, C. Sevgili, and R. Fiskin, "An analysis of severity of oil spill caused by vessel accidents." *Transportation Research Part D: Transport and Environment,* vol. 90, pp. 102662, Jan 2021.

[22] B. Kamal, "The use of fuzzy-bayes approach on the causal factors of empty container repositioning." *Marine Technology Society Journal,* vol. 55, pp. 20-38, Sep/Oct 2021.

[23] M. Aydin, E. Akyuz, O. Turan, and O. Arslan, "Validation of risk analysis for ship collision in narrow waters by using fuzzy Bayesian networks approach." *Ocean Engineering,* vol. 231, pp. 108973, July 2021.

[24] S. Pristrom, Z. Yang, J. Wang, and X. Yan. "A novel flexible model for piracy and robbery assessment of merchant ship operations." *Reliability Engineering and System Safety* vol. 155, pp. 196-211, Nov 2016.

[25] P. Weber, G. Medina-Oliva, C. Simon, and B. Iung. "Overview on Bayesian Networks Applications for Dependability, Risk Analysis and Maintenance Areas." *Engineering Applications of Artificial Intelligence,* vol. 25, pp. 671-82, June 2012.

[26] S. Mahadevan, R. Zhang, and N. Smith. "Bayesian Networks for System Reliability Reassessment." *Structural Safety,* vol. 23, pp. 231-51, Sep 2001.

[27] E. Zarei, M. Yazdi, R. Abbassi, and F. Khan. "A hybrid model for human factor analysis in process accidents: FBN-HFACS." *Journal of Loss Prevention in the Process Industries,* vol. 57, pp. 142-55, Jan 2019.

[28] L.A. Zadeh, "Fuzzy Sets." *Information and Control* vol. 8, pp. 338-53, June 1965.

[29] H-M. Hsu, and C-T. Chen. "Aggregation of fuzzy opinions under group decision making." *Fuzzy Sets and Systems*, vol. 79, pp. 279-85, May 1996.

[30] M. Aydin, G. Camliyurt, E. Akyuz, and O. Arslan, "Analyzing human error contributions to maritime environmental risk in oil/chemical tanker ship." *Human and Ecological Risk Assessment: An International Journal*, vol. 27, pp. 1-22, May 2021.

[31] S. Rajakarunakaran, A.M. Kumar, and V.A. Prabhu. "Applications of Fuzzy Faulty Tree Analysis and Expert Elicitation for Evaluation of Risks in LPG Refuelling Station." *Journal of Loss Prevention in the Process Industries,* vol. 33, pp. 109-23, Jan 2015.

[32] B. Kamal, G. Kara, and O. Okşaş, "An Application Of Fuzzy Analytic Hierarchy Process To Overcapacity Absorbing Methods In Container Shipping." *International Journal of Maritime Engineering,* vol. 162, pp. 331-44, 2020.

[33] Y. E. Senol, and F. Yasli, "A risk analysis study for chemical cargo tank cleaning process using Fuzzy Bayesian Network." *Ocean Engineering,* vol. 235, pp. 109360, June 2021.

[34] B. Kamal, and Ş. Kutay, "Assessment of causal mechanism of ship bunkering oil pollution." *Ocean & Coastal Management,* vol. 215, pp. 105939, Dec 2021.

[35] S. Sarıalioğlu, Ö. Uğurlu, M. Aydın, B. Vardar, and J. Wang. "A hybrid model for human-factor analysis of engine-room fires on ships: HFACS-PV&FFTA." *Ocean Engineering,* vol. 217, pp. 107992, Dec 2020.

[36] W-J. Wang, "New Similarity Measures on Fuzzy Sets and on Elements." *Fuzzy Sets and Systems,* vol. 85 pp. 305-9, Feb 1997.

[37] C. Şakar, and Y. Zorba. "A Study on Safety and Risk Assessment of Dangerous Cargo Operations in Oil/Chemical Tankers." *Journal of ETA Maritime Science,* vol. 5 pp. 396-413, Dec 2017.

[38] Yin, Robert K. Case Study Research. Reprint, London: Sage Publication, 2014.

[39] K.M. Eisenhardt, "Building theories from case study research" *Academy Of Management Review,* vol. 14, pp. 532-550, Oct 1989.

[40] K. Mellahi, and A. Wilkinson, "Organizational failure: a critique of recent research and a proposed integrative framework." *International Journal of Management Reviews,* vol. 5, pp. 21-41, Apr 2004.

[41] O. Lukason, Characteristics of firm failure processes in an international context (Doctoral dissertation), 2016.

[42] "Analysis On Hanjin Group And Main Credit Issues". 2015. https://www.nicerating.com/common/fileDown.do?docId=1LOmbiLBYkv.

[43] M. Wackett, "Revealed: who's owed the most out of thousands of hanjin creditors - the loadstar". *The Loadstar,* 2016. https://theloadstar.com/revealed-largest-thousands-hanjin-creditors/.

[44] P.M. Panayides, and R. Wiedmer. "Strategic Alliances in Container Liner Shipping." *Research in Transportation Economics,* vol. 32, pp. 25-38, 2011.

[45] "UNCTAD". 2017. https://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf.

[46] "BRS Annual Review 2017". BRS Group. https://www.brsbrokers.com/flipbook_en2017/files/downloads/BRS-ANNUAL-REVIEW-2017_EN.pdf.

[47] T-W. Lee, "Restructuring of the economy and its impacts on the Korean maritime industry." *Maritime Policy and Management,* vol. 26, pp. 311-25, 1999.

[48] H.A. Thanopoulou, D-K. Ryoo, and T-W. Lee. "Korean liner shipping in the era of global alliances." *Maritime Policy and Management,* vol. 26 pp. 209-29, 1999.

[49] L. Jensen, "Maritime-News: Debate Over State Aid For Container Shipping Flares Anew". Joc.Com., 2020. https://www.joc.com/maritime-news/state-aid-inseparable-container-shipping_20200528.html.

[50] J. Lee, "Hanjin Lost 'Game Of Chicken' Among Global Shippers, Chairman Says". U.S., 2016. https://www.reuters.com/article/usJhanjinJshippingJdebtJidUSKCN1240JC?il=0#.

[51] G. Alexandrou, D. Gounopoulos, and H. M. Thomas, "Mergers and acquisitions in shipping." *Transportation Research Part E: Logistics and Transportation Review,* vol. 61, pp. 212-234, Jan 2014.

[52] C. Tan, *"The Economic Effects Of Huge Shipping Company - Hanjin Group'S Bankruptcies: Case Study On Hanjin Shipping Group (South Korea) Bankruptcy."* Master Thesis. University of South-Eastern Norway, 2018.

[53] "UNCTAD". 2018. https://unctad.org/system/files/official-document/presspb2018d6_en.pdf.

[54] D. Braden, "Shipper Exposure To Hanjin Collapse Goes Far Beyond CKYHE, Report Shows". The Journal of Commerce online. Sep 2016. https://www.joc.com/maritime-news/container-lines/shipper-exposure-hanjin-collapse-goes-far-beyond-ckyhe-report-shows_20160914.html.

[55] B. G. Marcot, "Metrics for Evaluating Performance and Uncertainty of Bayesian Network Models." *Ecological Modelling,* vol. 230, pp. 50-62, Apr 2012.

[56] R. Carter, and V. A. Howard, "Small Firm Bankruptcy." *Journal of Small Business Management,* vol. 44 pp. 493-512, Sep 2006.

[57] J. Ropega, "The Reasons and Symptoms of Failure in SME." *International Advances in Economic Research* vol. 17 pp. 476-83, July 2011.

[58] O. Lukason, and C. H. Richard, "Section 2. Management in Firms and Organizations: Firm Failure Causes: A Population Level

Study." *Problems and Perspectives in Management* vol. 13, pp. 45-55, March 2015.

[59] G. Hall, "Reasons for Insolvency amongst Small Firms - A Review and Fresh Evidence." *Small Business Economics,* vol. 4 pp. 237-50, Sep 1992.

[60] L. R. Gaskill, H. E. Van Auken, R. A. Manning. "A factor analytic study of the perceived causes of small business failure" *Journal of Small Business Management,* vol. 31, pp. 18-31, Oct 1993.

[61] D. Arditi, A. Koksal, and S. Kale. "Business Failures In The Construction Industry." *Engineering Construction And Architectural Management,* vol. 7, pp. 120-132, Feb 2000.

[62] J. Baldwin et al. 1997. "Failing concerns: business bankruptcy in Canada". Analytical Studies Branch, Statistics Canada.