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# FACTORS INFLUENCING FOLLOW-ON PUBLIC OFFERING OF SHIPPING COMPANIES FROM INVESTOR PERSPECTIVE – A HYBRID MULTIPLE-CRITERIA DECISION-MAKING APPROACH

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**Abstract.** The shipping industry transports nearly 80% of the goods worldwide and requires large funding. The shipping industry shifted from debt to equity as the source of funding in the last decade. Because most shipping companies already had their initial public offering before 2013, these companies tend to engage in follow-on equity offerings (FPO). However, the challenge faced by the shipping companies is the lack of knowledge on successful FPO. The purpose of this study is to identify the most influential factors affecting shipping companies' FPO from the investor perspective. This research applies a hybrid multiple-criteria decision-making model integrating the fuzzy-Delphi method and Decision-Making Trial and Evaluation Laboratory, processing survey responses covering four dimensions and 16 criteria from 33 investment experts. The results show that financial indicator is the primary cause affecting offering condition, technical indicators. An increase in earnings per share would help the financial performance of the shipping companies to appear most attractive to investors.

**Keywords:** shipping industry, shipping finance, follow-on equity offering (FPO), share capital increase, multiple-criteria decision-making (MCDM), fuzzy DEMATEL.

**JEL Classification:** F23, G15, G24, G32, L91.

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## 1. Introduction

The international shipping industry is vital to the global economy because shipping companies transport nearly 80% of the international trade. Moreover, shipping by the sea not only establishes lower transportation cost but also provides the least environmentally harmful way of transportation with minimum marine pollution (International Maritime Organization, 2022). Figure 1 illustrates the world seaborne trade volume from 2005 to 2019 in millions of tons (United Nations Conference on Trade and Development [UNCTAD], 2020).

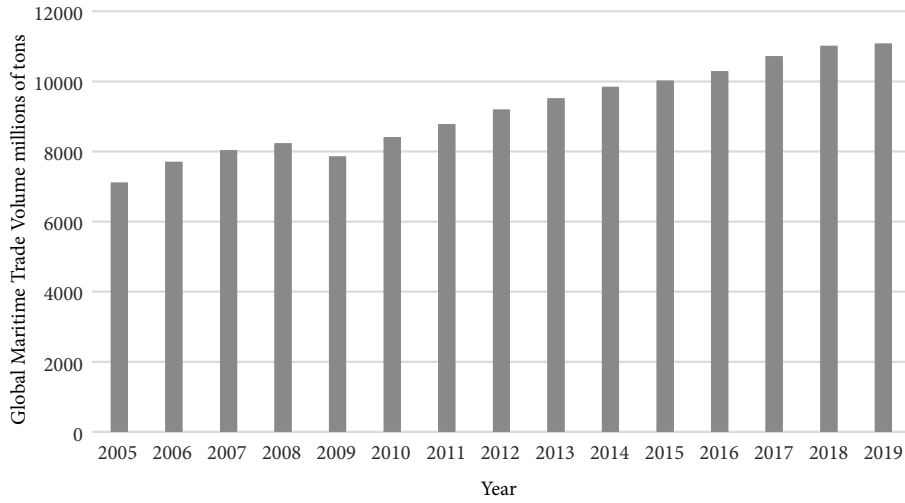


**Figure 1.** Global equity financing by type from 2005 to 2019 in US$ million

From the shipping finance perspective, the shipping industry requires a substantial amount of fund to sustain its capital-intensive business. According to the United Nations Conference on Trade and Development (UNCTAD), shipping companies around the world operated over 53,000 ships in 2021 (United Nations Conference on Trade and Development (UNCTAD, 2022). These vessels carried over 2 trillion dead-weight tons (dwt) in 2021, which represented a 17.8% growth from 2016. The global shipping companies need massive amounts of funds to construct new vessels with the cost of building one ship frequently exceeding US$200 million (Kavussanos & Visvikis, 2016). According to Delaney (2022), the global shipping companies altogether ordered 1,286 vessels (container, tanker, and dry bulk carriers) in 2021, which represented a 32.7% increase from the 969 vessels in 2020. Moreover, with the substantial price increase for certain vessels, the total value of the vessels ordered in 2021 reached US$91.61 billion, constituting a 114% increase compared to the amount of US$42.83 billion in 2020.

Shipping companies may acquire second-hand ships instead of building new ships to lower their capital expenditure and the risk of a potential market downturn. Dixon (2022) reported that second-hand vessel purchases reached a new record of more than US$47 billion in 2021 and he anticipates the amount to rise in 2022. Furthermore, based on the forecast in Maritime Logistics Market Report (2022), the global maritime logistics market is expected to grow at a compound annual growth rate (CAGR) of 4.5% from 2021 to 2030.

The shipping companies raise large funds mainly through two ways: debt and equity. The literature discussed shipping companies' capital structure, which is defined as the amount of debt and equity employed by a firm to fund its business operations and finance its assets (Drobetz et al., 2013). The capital structure of firms can be explained by three theories: the trade-off theory, the market-timing theory, and the growth-opportunity theory. The trade-off theory assumes that capital structure options are determined by the trade-off between the benefits and costs of debt (Kraus & Litzenberger, 1973). The market-timing theory empha-

sizes the importance of timing in the international financial markets. Thus, shipping companies decide to finance through debt or equity depending on which option is more effective in raising funds from the capital markets (Baker & Wurgler, 2002). The growth-opportunity theory attributes equity financing decisions to promising investment opportunities in a company (Le et al., 2020).

In the history of shipping finance, the shipping companies shifted from debt to equity in the last decade. The advantages of public equity include the lower cost of capital and flexibility (Alexandridis et al., 2018, 2020) compared to bank loans and bonds which obligate shipping companies to pay fixed interest payments. In the 2000s, the trend of globalization led to the rapid growth of the shipping industry. Initially, most shipping companies secured bank loans but quickly realized that loans were insufficient to support their future expansions. Therefore, shipping companies resorted to equity financing with 81 shipping companies engaged in an initial public offering (IPO) from 2003 to 2007 (Drobetz et al., 2017). After the 2008 global financial crisis, however, banks hesitated to grant loans to shipping companies with the increased default risk in the market. Subsequently, a greater number of shipping companies diversified their financing sources through equity (Alexandridis et al., 2018).

Global shipping equity financing can be divided into three types: private placement, IPO, and follow-on equity offering (FPO) (Daniel & Yildiran, 2019). FPO, also known as seasoned equity offering, refers to the additional offering of shares by a company after its IPO. According to Daniel and Yildiran (2019), the stability of the funds raised through the three equity financing methods varied. First, IPO of the shipping companies surged to US$19 billion in 2007 (pre-2008 global financial crisis) but dropped to US$7 billion in 2010, and US$10 billion in 2011 (post-2008 financial crisis). Afterward, IPO further subsided after 2013 with most shipping companies completing their initial offerings already. Similarly, private placement fluctuated from its highest total amount of US$7 billion in 2011 to a low level of US$1 billion in 2012. In contrast, FPO remained steady from 2007 to 2017 at around US$5 billion each year, providing a stable source of funds to the existing shipping companies. Figure 2 exhibits the global shipping equity by type from 2007 to 2017 in USD million (Daniel & Yildiran, 2019).

The shipping companies announce their share capital increases through cash payments from the investors mainly for three purposes to support their businesses. For instance, in 2017, a German shipping company increased its share capital by approximately US$414 million in cash to repay its debts and support its normal business operation. During the same year, a Taiwanese shipping company increased its capital by US$253 million in cash to purchase the new vessels.

Since 2019, the demand for shipping financing further increased. Toward the end of 2019, a type of coronavirus (later named COVID-19) erupted in Wuhan, China quickly spread over the world because of the high transportation connectivity (Michail & Melas, 2020). The COVID-19 pandemic caused countries around the world to close their borders, extend waiting times at the customs, and delay shipments due to labor shortage and port congestion because of the tight regulations. Consequently, the shipping costs and rates rose in 2020 and 2021, boosting the profits and stock prices of some shipping companies. Severe Covid-19 conditions heighten the need of the shipping companies to expand their fleet through share

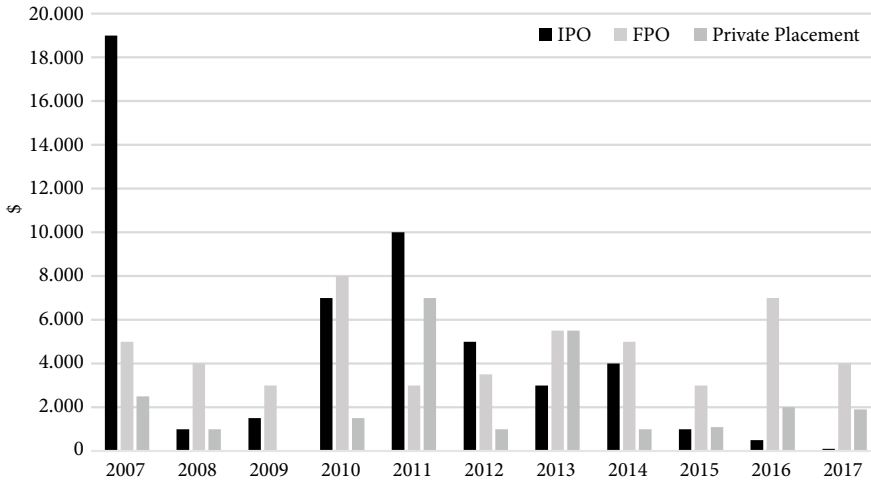


**Figure 2.** Global equity financing by type from 2007 to 2017 in US$ million

capital increase and their retained earnings (Miller, 2019). Between December 2019 and February 2022, eight international shipping companies increased their share capital through cash payments from investors, raising more than US$700 million. For example, in 2021, a Taiwanese shipping company doubled its revenue during the 2020 Covid-19 period by higher freight charges and quickly increased its cash by approximately US$3.29 billion (NTD92.12 billion) through the offering of additional shares to investors (Liu, 2021). Subsequent to these successful share capital increases, Miller (2019) reported that financial analysts anticipated more FPOs would appear after 2020 because the shipping companies need more funds, especially when their stock prices rise (Miller, 2019).

The extant literature discussed shipping finance regarding capital structure, loans, private placement, and IPOs (Alexandridis et al., 2020; Drobetz et al., 2013, 2017; Grammenos & Papapostolou, 2012; Lee & Pak, 2018; Maniati & Sambracos, 2017). However, scant research analyzed the FPOs of the global shipping companies and the factors affecting the success of such secondary offerings. This paper aims to fill the research gap. Therefore, the purpose of this research is to identify factors influencing FPOs of global shipping companies from investors' perspectives using a hybrid multiple-criteria decision-making (MCDM) approach integrating the fuzzy set theory and Decision-making Trial and Evaluation Laboratory (DEMATEL) model.

Based on the literature, we select four dimensions (financial indicator, technical indicators, investor sentiment, and offering condition) and 16 criteria. We first apply the fuzzy-Delphi method elucidated by Yalcin et al. (2020), and then distribute survey questionnaires to 33 investment experts working at financial institutions. The empirical results reveal the results in two ways: the degree of influence and the cause-and-effect relationship. In terms of the degree of influence, offering condition is the most influential dimension, followed by financial indicator, technical indicator, and investor sentiment. Regarding the cause-and-effect relationship, financial indicator is the greatest cause, followed by offering condition and technical

indicators while investor sentiment is the effect. In addition, within the dimension of financial indicator, EPS is the most influential criterion and the greatest cause. Within the dimension of offering condition, prospective value is the most important criterion and the greatest cause.

These findings imply that shipping companies should focus on offering condition because it has the highest influence. To improve offering condition, shipping companies may improve the financial indicator of EPS, which would in turn influence the prospective value perceived by the investors. The results of this study are consistent with the market-timing theory and the growth-opportunity theory that companies should resort to equity financing when they can raise more funds from the stock markets. The outcome of this research benefits shipping companies that desire to increase their share capital by cash.

This paper contributes to the shipping finance literature in four ways. First, to the best of our knowledge, this paper is the first one to analyze FPOs of international shipping companies. In particular, the study selects four dimensions and 16 criteria to identify the most influential factors affecting the secondary offerings of global shipping companies from investor perspective. Second, this study engages 33 investment experts each with more than ten years of work experiences at financial institutions. To avoid inconsistency and incomparability in the language expressions among the experts, this study utilizes a personalized semantic scale for each investment expert to obtain his or her true meaning of speech. Third, we perform a pre-test on the survey to ensure experts' agreement on the pre-selected four dimensions and 16 criteria before finalizing the questionnaire. After the survey, we perform a consensus test on the expert opinions to prove the validity of the collective survey responses. Fourth and last, we apply the fuzzy-DEMATEL method to process the interconnected complexity among the four dimensions and 16 criteria not only to identify the most influential factors, but also to find the cause-and-effect relationship. Based on the findings of this paper, we provide practical suggestions to the shipping company managers who desire to increase corporate capital through issuing additional shares.

The remainder of this study is structured as follows. Section 2 reviews prior literature. Section 3 describes data and methodology. Section 4 reports the empirical results and discusses the implications. Section 5 concludes the paper with limitations and future research.

## 2. Review of literature

### 2.1. Theoretical framework and equity financing

Capital structure is defined as the amount of debt and/or equity used by a firm to fund its operations and finance its assets (Corporate Finance Institute, 2022a). The main theories which attempt to elaborate a firm's capital structure include the trade-off theory, the market-timing theory, and the growth-opportunity theory.

The trade-off theory argues that corporations determine their capital structure by a trade-off between the benefits of costs of debt (Kraus & Litzenberger, 1973). This theory considers a balance between the costs of bankruptcy due to debt and the tax-saving benefits of debt. When the debt-to-equity ratio (leverage) increases, a trade-off problem emerges between tax-saving from interest and the possibility of bankruptcy from fixed interest payments. A

corporation must reach an optimum capital structure to balance the tax-shield gains of debt financing and the costs of bankruptcy. However, Modigliani and Miller (1959) proposed the capital structure irrelevance principle in an efficient market, claiming that the capital structure does not affect the value of a firm. Instead, the market value of a corporation depends solely on its operating profits.

While the trade-off theory aims to find the optimal debt and equity combination with market imperfections such as taxes and financial distress costs, Baker and Wurgler (2002) propose the market-timing theory which uses market timing to determine a corporation's capital structure rather than allocating debt and equity in a pre-determined proportion. According to the market-timing theory, firms do not insist on financing through equity or debt. Instead, companies select the means of financing that benefits them more in the current market condition. When the stock market seems more promising, and the market-to-book ratio is relatively high, corporate managers are likely to choose equity over debt because equity is valued more by the financial markets during such a period. By issuing stock in the capital markets, firms can maximize the amount of cash raised. Hence, the firm's capital structure is not a static optimization but a flexible investment strategy to capitalize on the favorable timing of the equity market.

The growth opportunity theory proposed by Myers (1977) expounds corporate decisions to offer equity when they have found promising investment opportunities in the firms. Most firms are treated as going concerns; therefore, the net present values of the net cash flows from future projects determine the firm value. The firms financed with interest-bearing debt may forgo valuable investment opportunities which could generate positive net cash flow. Thus, issuing debt with fixed interest payment reduces the present value of the firm, which is suboptimal to corporate financial planning. Consequently, the current stockholders absorb the potential loss in the market value caused by underinvestment. Furthermore, investors regard investment projects as positive news because these projects could boost stock prices. Therefore, a corporation with a perceived growth potential would prefer financing its investment projects through equity offering rather than debt in the absence of taxes.

Corporations issue stocks to the public in two forms: IPOs and FPOs. IPO referred to the first issue of stocks. FPO, also known as a secondary offering and seasoned equity offering, is defined as the additional offering of shares by the company after its IPO in the stock markets (Shraddha, 2022). Under an FPO, companies could offer new shares to either new investors (diluted) or their existing shareholders (non-diluted). Companies initiate a share capital increase mainly for four reasons: purchase new or second-hand vessels, pay off existing debts, increase working capital, and engage in a merger and acquisition.

After the 1990s, the shipping industry started to finance in the equity markets because shipping managers consider public investors as a vital source of capital. The estimated share of public equity including IPOs and FPOs constituted approximately 8% of the total funds raised by the shipping industry from 2007 to 2017 (Alexandridis et al., 2018). The advantage of equity financing over debt includes interest-free financing and continuity in funding. After 2007, the shipping industry increased share capital to raise cash through FPOs (Daniel & Yildiran, 2019). Moreover, Drobetz et al. (2021) argue that institutional investors add shipping

stock in their portfolios to control shipping companies, diversify risk, increase short-term gain, or utilize passive investing strategy. These findings correspond to the growth opportunity theory.

Prior literature mostly focused on shipping IPOs. Grammenos and Papapostolou (2012) revealed that IPO prospectus and market information partly determined the final IPO price of the shipping companies. Pribor and Lind (2016) claimed that the success of shipping IPOs after the 2008 financial crisis was the result of favorable freight market conditions. Drobetz et al. (2017) found that the IPO prospectus with earnings forecast propelled the public investors to invest in shipping firms. Similarly, Drobetz et al. (2017) argued that IPOs were underpriced less in countries where public firms produce quality information on earnings. Such findings correspond to the market-timing theory.

## 2.2. Factors in equity offering

The extant literature described a multitude of factors that influenced shipping stock selection (Alexandridis et al., 2020; Bazaluk et al., 2022; Drobetz et al., 2013; Paun & Topan, 2016). We classify those factors into four dimensions: financial indicator, technical indicator, investment sentiment, and offering condition.

We start in Section 2.3 with financial indicator. Barclay et al. (2021) assumed that investors are rational and refer to the firm's financial statements, particularly balance sheet and income statement, to decide on FPOs. The fundamental analysts evaluate the financial condition of a business to compare the intrinsic value of the stock with its market price (Alexandridis et al., 2020; Petropoulos, 2020). The most common fundamental analysis indicators are divided into two categories. The first category is the market value ratios, such as the price-earnings ratio (P/E ratio) and price-to-book ratio (P/B ratio). The second category is the investor ratios, which are used to measure the return on invested capital.

Section 2.4 describes the technical indicators. Technical analysis is a trading method to identify trading opportunities by analyzing prices and trading volume collected from past trading activities (Corporate Finance Institute, 2022d). Chart patterns and technical indicators aid technical analysts to predict the future market price of a stock. The commonly used technical indicators include the KD indicator, relative strength index (RSI), bias, and moving average convergence divergence (MACD).

Section 2.5 presents the investment sentiment indicator. Investor sentiment, also known as market sentiment, refers to the general perception of investors toward the market expressed as bullish or bearish (American Association of Individual Investors, 2022). Short-term investors, financial, and technical analysts typically consider investor sentiment when evaluating an investment in the short run. Investor sentiment is affected by investors' emotions, economic events, and media coverage (American Association of Individual Investors, 2022). Investor sentiment can be signaled by momentum, reference point, volume, and turnover rate (Hao et al., 2018).

Section 2.6 explains the offering condition (Barclay et al., 2021; Chen et al., 2019). Prospective value, price discount, offer size, and lock-in period typically influence the success of the equity issuance of a company.

## 2.3. Financial indicator

*P/E ratio:* The P/E ratio is a measure that indicates the number of times the current share price of a stock is over EPS, indicating the value of the firm. A higher P/E ratio suggests higher expectations of the investors toward the future earnings of the company (Corporate Finance Institute, 2020c). Based on the market-timing theory, investors anticipate the firms with a higher P/E ratio to produce greater profits in the future; therefore, the investors are willing to purchase the shares at a higher price. Abuselidze and Slobodianyk (2021) argued that a higher P/E ratio permits companies to raise more cash from investors through positive outlook. From the growth potential perspective, Herawati and Angger (2018) asserted that companies with promising future business projects are more likely to increase their current market prices, thus attracting optimistic equity investors.

*Price-to-book ratio:* The P/B ratio measures a firm's growth opportunities. Growth firms are expected to see a higher market price-to-book ratio because the investors are willing to pay a higher price for the stock. A higher price-to-book ratio suggests an inverse relationship between the price-to-book ratio and debt under the growth-opportunity theory because growth firms are expected to suffer from a potential underinvestment problem due to interest-bearing debt. (Myers, 1977). The literature further corresponds to the market-timing theory with the price-to-book ratio compelling the companies to issue equity rather than debt to benefit from the higher valuation of the equity (Vuković et al., 2020).

*Return on equity*: Return on equity (ROE) measures firm profitability in percentage. Given lower costs of financial distress and a higher income in more profitable firms, the trade-off theory describes a potential positive relationship between profitability and debt because the firms have higher abilities to pay taxes. In contrast, the marketing-timing theory suggests that investors prefer equity to debt when they hold optimistic views about firms' earnings in the future (Baker & Wurgler, 2002). The literature supports the latter conjecture (Paun & Topan, 2016; Woo et al., 2020).

*EPS*: EPS is another profitability indicator but cannot be compared across the companies because it is expressed in an absolute number. EPS, computed by earnings divided by the number of outstanding shares, is positively related to share price and market capitalization. Similar to ROE, the trade-off theory suggests that firms with higher EPS could benefit from the tax shield of debt interest. However, the market-timing theory implies that firms should seize the opportunity to raise more funds when the equity market grows more favorable. Previous researchers alleged that EPS tends to shift companies from debt to equity (Vuković et al., 2020; Woo et al., 2020).

## 2.4. Technical indicator

*The KD indicator*, also known as the stochastic oscillator, is a two-line graph composed of K value and D value. The KD indicator is used to predict changes in stock trends and price patterns in stock. The main line is "%K" while the second line is "%D" which represents the moving of %K. The value of %K and %D lines show whether the stock is overbought (over 80) or oversold (below 20) (Iqbal, 2023). Alexander (1961) first proposed the filter rules by using the turning points investors buy with a rise in asset prices of X% but sell after a fall in

asset prices of Y%. Prior studies used technical indicators to analyze the sale and purchase of second-hand vessels and the herding behavior of shipping company stock returns (Chou & Chen, 2019; Makrominas, 2018).

*RSI*: The relative strength index (RSI), developed by Wilder (1978), is a momentum oscillator that measures the speed at which stock price changes. RSI is used to determine the volatility of the price movements and predict the stock prices in the future, thus identifying stock overbought and oversold situations. Bollinger (2002) used patterns and trends in asset prices to determine the timing for purchasing vessels.

*Bias*: Bias is also known as deviation that measures the distance between the stock price and the moving average which is a trend line. Bias increases when asset prices diverge from the moving average, leading to a strong correction of asset prices (Malkiel et al., 2005). A positive bias means that stock investment is profitable while a negative one suggests that the investment is unfavorable. Chou and Chen (2019) described the use of deviation to determine the optimal timing to purchase second-hand vessels in the market.

*Moving average convergence divergence* (*MACD*): The MACD indicator is a momentum oscillator used to predict trade trends. This indicator consists of two lines that oscillate without boundaries. The crossover of the two lines signals trade timing (Fidelity, 2022). Prior literature used mostly moving averages to determine whether a particular stock is bullish or bearish, thus avoiding trading in unfavorable market timing (Makrominas, 2018; Michail & Melas, 2019).

## 2.5. Investor sentiment

Investor sentiment indicators are psychology-based ratios that quantify investor mood toward the stock market and could affect stock prices (Ehlert, 2022). Syriopoulos and Bakos (2019) argued that investor sentiment could drive investor herding behavior, thus affecting stock prices.

*Momentum*. The momentum is a short-term technical indicator that tracks the speed at which stock prices rise and fall. Kim and Sub (2018) found that investor sentiment cased the momentum of stock in the capital markets. When a momentum index shows positive number, the stock price is on an upward trend. When the momentum index turns negative, the stock price is declining. In general, a higher momentum reflects a more optimistic investor sentiment (Lan et al., 2021). Previous studies used momentum index to predict stock prices and found investor sentiment affected trading (Syriopoulos & Bakos, 2019; Wu et al., 2021).

*Reference point*. The reference point model, developed by Tversky and Kahneman (1991), argues that the stock is evaluated relative to its reference point, such as a 10-day moving average. Investors perceive the stock price as either positively or negatively relative to its reference points, rather than for its actual market value. Previous researchers included the reference point effect to evaluate the relationship between investor sentiment and stock prices and found a connection between them (Hu & Gong, 2018; Kwon & Lee, 2009).

*Trading volume*. Trading Volume refers to the value of a stock being bought and sold in the financial market. Prior researchers studied the relationship between trading and investment sentiment. The results reveal a positive relationship between trading volume and

investor sentiment. Trading volume reflects the level of investor participation. Higher trading volume suggests greater optimism held by the investors (Chen et al., 2019; Syriopoulos & Bakos, 2019).

*Turnover rate*. The stock turnover ratio is the percentage of a particular stock or a portfolio of stocks that have been replaced in a particular year. For instance, when an investor invested in 10 stocks and replaced 5 stocks during the last 12 months, the turnover ratio was 50%. Previous authors found that turnover rate significantly affects investor sentiment. The turnover rate can be used as a proxy to predict stock price because a higher turnover rate possibly means greater panic in the market with emotional investors trading more than usual, thus lowering the stock prices (Lee, 2019; Liu et al., 2020).

## 2.6. Offering condition

*Prospective value*. Prospective value is defined as the stock market value perceived by investors at a certain future date. The prospect theory proposed by Kahneman and Tversky (1979) argues that prospective value reflects investors' outlook on the stock price in relation to changes in their wealth. Prospective value is the relative market value based on the opinions of investors at a fixed future date. Prior researchers claimed that the prospective value of a particular stock influenced investor decisions about stock selection, which corresponds to the growth-opportunity theory (Barberis et al., 2016; Ohk & Ju, 2021).

*Price discount*. Price discount refers to the percentage of discount offered to investors during a company's FPO. Discounting is the logarithm of the ratio of the closing market price the day before an FPO to the offer price (Petropoulos, 2020). Corwin (2003) uncovered that FPO offers were underpriced over time and that underpricing is positively related to the offering size. Bowen et al. (2008) and Lang (2008) studied the relationship between price discounts and secondary offering, highlighting that price discount is the result of information asymmetry between managers and investors.

*Offer size*. Offer size refers to the percentage of additional shares during an FPO in the total number of existing shares. Offer size is calculated by the number of offered shares divided by the total number of shares outstanding before SEO. Offer size can be interpreted positively and negatively (Bowen et al., 2008; Lang, 2008). Investors may regard a larger offer size as a signal for the company to expand its business. Conversely, a larger offer size probably means that the company is faced with financial distress and unable to support its business with its retained earnings. Chan et al. (2018) found an increase in offer size leads to higher FPO performance.

*Lock-in period*. The lock-in period is defined as the pre-determined time frame in which investors are restricted from selling after an FPO (Corporate Finance Institute, 2022b). The purpose of a lock-in period is to stabilize the funds received by the issuing company because excessive selling would reduce the liquidity of the company that needs the funds for a specific business purpose. The lock-in period requires investors to hold their investments for a certain period to possibly profit from long-term investment. Prior studies found a positive relationship between the lock-in period and excess returns of FPOs in some industries (Kecskés, 2019; Talans & Accioly Fonseca Minardi, 2021).

## 3. Methodology

Previous researchers mainly used regression, stochastic approach, and Altman's Z-score to examine the capital structure and IPOs of shipping companies (Alexandridis et al., 2020; Bazaluk et al., 2022; Drobetz et al., 2017; Maniati & Sambracos, 2017; Paun & Topan, 2016). The conventional methods assume that all factors are independent and equally important. In contrast, the MCDM model identifies the dependence among factors. This study develops a hybrid MCDM model incorporating the fuzzy set theory and the DEMATEL method.

The Delphi method proposed by Dalkey and Helmer (1963) is used to gather opinions from experts in a specific field. The fuzzy set theory proposed by Zadeh (1971) examines fuzzy linguistic terms. The fuzzy theory emphasizes that human thinking and language cannot be easily quantified using precise numbers or ratios. Therefore, Zadeh (1971) developed the fuzzy method to process human-centered problems with ambiguity in languages. The incorporation of the fuzzy set theory in the Delphi method, known as the fuzzy-Delphi method, can deal with uncertainty and vagueness in survey questions and responses (Murray et al., 1985).

The DEMATEL method, first proposed by Fontela and Gabus (1976), originated from the Battelle Memorial Institute Geneva for two purposes. First, the DEMATEL method can be used to analyze complex problems. Second, this method can evaluate qualitative and factor-linked aspects of the issue. The DEMATEL technique induces a pairwise influential network relation map (INRM) to detect the interrelationships among specific dimensions and criteria. Previous authors used the MCDM method to investigate shipping registry selection and credit risk (Chou, 2018; Kramberger et al., 2016).

### 3.1. Dimensions and criteria

Based on the literature review, we select the following dimensions and criteria to identify the most influential factors influencing the FPOs of shipping companies. Table 1 summarizes the dimensions and criteria for evaluating shipping FPOs.

### 3.2. Demographics of experts

We select 33 investment experts consisting of institutional investors and financial managers. The experts have all accumulated more than 10 years of work experiences at financial institutions. Table 2 presents the demographics of the experts.

### 3.3. Research framework

The study applies the fuzzy-DEMATEL method to identify the factors affecting shipping FPOs. This method is conducted in two stages. During the first stage, we apply the fuzzy logic to process the expert opinions.

During the second stage, we utilize the DEMATEL method to identify the relationships among the dimensions and criteria. Figure 3 depicts the research framework of the fuzzy DEMATEL model based on a study by Chen et al. (2011).

**Table 1.** Dimensions and criteria for evaluating shipping FPOs

| Dimension/Criteria | | Definition |
|---|---|---|
| Financial Indicator ($D_1$) | | |
| $C_{11}$ | P/E ratio | Market value/earnings per share. |
| $C_{12}$ | P/B ratio | Market value/book value. |
| $C_{13}$ | ROE | Net income/common equity. |
| $C_{14}$ | EPS | Net income/number of shares. |
| Technical Indicator ($D_2$) | | |
| $C_{21}$ | KD indicator | A two-line graph composed of the "k" value and "d" value. It identifies overbought and oversold conditions. |
| $C_{22}$ | RSI | The relative strength index measures the speed of stock price changes. |
| $C_{23}$ | Bias | The distance between stock price and moving average, also known as deviation. |
| $C_{24}$ | MACD | MACD stands for moving average convergence divergence. It indicates the buy signal in which the shorter-term 12-period exponential moving average (EMA) crosses over the longer-term 26-period EMA. |
| Investor Sentiment ($D_3$) | | |
| $C_{31}$ | Momentum | An indicator that tracks the speed at which stock prices rise and fall. |
| $C_{32}$ | Reference Point | A point at which stock price is valued against. |
| $C_{33}$ | Volume | The total value of the stock being bought and sold in one day. |
| $C_{34}$ | Turnover Rate | The percentage of stocks that have been replaced in the last 12 months. |
| Offering Condition ($D_4$) | | |
| $C_{41}$ | Prospective Value | Stock value perceived by investors at a certain future date. |
| $C_{42}$ | Price Discount | The percentage of discount offered to investors during an FPO. |
| $C_{43}$ | Offer Size | The percentage of additional shares during an FPO in a total number of existing shares. |
| $C_{44}$ | Lock-in Period | The pre-determined time frame in which investors are restricted from selling after an FPO. |

**Table 2.** Demographics of the 33 experts

| Type | | | Category | | Number of experts | |
|---|---|---|---|---|---|---|
| Gender | | | Male | | 24 | |
| | | | Female | | 9 | |
| Education | | | Ph.D. | | 2 | |
| | | | Master | | 19 | |
| | | | Bachelor | | 12 | |
| Age | | | 30–39 | | 1 | |
| | | | 40–49 | | 23 | |
| | | | 50–59 | | 9 | |
| Years of Investment | | | 11–15 years | | 10 | |
| | | | 16–20 years | | 8 | |
| | | | 21–25 years | | 11 | |
| | | | 26–30 years | | 3 | |
| | | | Over 30 years | | 1 | |
| Position | | | Assistant Manager | | 13 | |
| | | | Manager | | 15 | |
| | | | Senior Manager | | 4 | |
| | | | President | | 1 | |
| Seq | Gender | Age | Education | Position | Years of Experience | Securities Firm |
| 1 | M | 30–39 | Bachelor | Assistant Manager | 11–15 | Bank of Taiwan Securities |
| 2 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | Capital Securities |
| 3 | F | 40–49 | Bachelor | Assistant Manager | 11–15 | Grand Fortune Securities |
| 4 | F | 40–49 | Bachelor | Assistant Manager | 11–15 | SinoPac Securities |
| 5 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | MEGA Securities |
| 6 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | Cathay Securities |
| 7 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | Yuanta Securities |
| 8 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | First Securities |
| 9 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | Taiwan Cooperative Securities |
| 10 | M | 40–49 | Bachelor | Assistant Manager | 11–15 | IBF Securities |
| 11 | F | 40–49 | Bachelor | Assistant Manager | 16–20 | MasterLink Securities |
| 12 | M | 40–49 | Bachelor | Assistant Manager | 16–20 | President Securities |
| 13 | F | 40–49 | Bachelor | Assistant Manager | 16–20 | Fubon Securities |
| 14 | M | 40–49 | Master | Manager | 16–20 | Bank of Taiwan Securities |

*End of Table 2*

| Type | | | Category | | Number of experts | |
|---|---|---|---|---|---|---|
| 15 | F | 40–49 | Master | Manager | 16–20 | Capital Securities |
| 16 | M | 40–49 | Master | Manager | 16–20 | Grand Fortune Securities |
| 17 | M | 40–49 | Master | Manager | 16–20 | SinoPac Securities |
| 18 | F | 40–49 | Master | Manager | 16–20 | MEGA Securities |
| 16 | M | 40–49 | Master | Manager | 21–25 | Cathay Securities |
| 20 | M | 40–49 | Master | Manager | 21–25 | Yuanta Securities |
| 21 | F | 40–49 | Master | Manager | 21–25 | First Securities |
| 22 | M | 40–49 | Master | Manager | 21–25 | Taiwan Cooperative Securities |
| 23 | M | 40–49 | Master | Manager | 21–25 | IBF Securities |
| 24 | F | 50–59 | Master | Manager | 21–25 | Taichung Bank Securities |
| 25 | M | 50–59 | PhD | Manager | 21–25 | MasterLink Securities |
| 26 | M | 50–59 | Master | Manager | 21–25 | President Securities |
| 27 | M | 50–59 | Master | Manager | 21–25 | Fubon Securities |
| 28 | F | 50–59 | PhD | Manager | 21–25 | KGI Securities |
| 29 | M | 50–59 | Master | General Manager | 21–25 | Bank of Taiwan Securities |
| 30 | M | 50–59 | Master | Chief Secretary | 26–30 | Bank of Taiwan Securities |
| 31 | M | 50–59 | Master | Vice President | 26–30 | Capital Securities |
| 32 | M | 50–59 | Master | Vice President | 26–30 | Grand Fortune Securities |
| 33 | M | 50–59 | Master | Chairman of Board | Over 30 | Bank of Taiwan Securities |

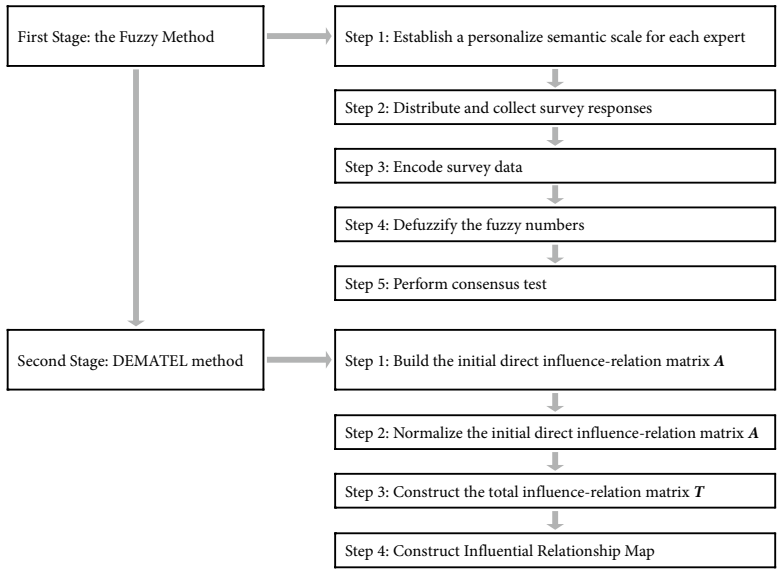


**Figure 3.** Framework of the Fuzzy-DEMATEL model

### *3.3.1. Stage 1: The fuzzy method*

The fuzzy method is adopted to analyze expert opinions. Different experts may use different words or vague linguistic terms to express their meanings. We process each expert's opinions independently and finally aggregate the responses. The fuzzy method is divided into five steps.

#### Step 1: Establish a personalize semantic scale for each expert

We first establish a distinct fuzzy semantic scale for each expert considering the variations of the expert opinions due to the differences in human language expressions. Unlike the traditional total influence-relation matrices in which the setting of threshold values was necessary because the matrices process all 16 criteria in the same 16×16 matrix. In this study, we use a novice approach. We set an individual scale for each expert. The personalized semantic scale for each expert should capture his or her unique language expression and the corresponding meaning. We use a smaller 4×4 matrix to examine the four dimensions and criteria under each dimension. The smaller matrices do not necessitate the setting of threshold values. The advantage of using smaller matrices is that we would not inadvertently eliminate factors that could be influential.

The computational technique for experts' opinions is based on the fuzzy number defined by Mon et al. (1994). A fuzzy number does not refer to one single number but a connected set of values. Each membership function, also known as the scale of fuzzy number, is defined by three parameters of the symmetric triangular fuzzy number, the left point, middle point, and right point of the range over which the function is defined. The triangular fuzzy number can encompass expert opinions where the maximum and minimum values are computed as the two terminal points.

According to Chen et al. (2011) and van Laarhoven and Pedrycz (1983), a fuzzy number $\tilde{O}\,\Psi$ is defined as a triangular fuzzy number if it is membership function $\varepsilon \in \tilde{O}, \mu_{\tilde{O}}(\varepsilon): \Psi \to [0,1]$ is expressed in Eq. (1):

$$A\mu_{\tilde{O}}(\varepsilon) = \begin{cases} (\varepsilon - l)/(m-l), l \le \varepsilon \le m \\ (\mu - \varepsilon)/(\mu - m), m \le \varepsilon \le \mu, \\ 0, \quad \text{otherwise} \end{cases} \tag{1}$$

where $l$ stands for lower bounds, $u$ for upper bounds, and $m$ for the middle value of the fuzzy number $\tilde{O}$. The triangular fuzzy number can be denoted by $\tilde{O} = (l,m,u)$. Thus, every expert is given a triangular fuzzy number. Table 3 exhibits the personalized fuzzy semantic scale for each of the 33 experts.

**Table 3.** Personalized fuzzy semantic scale for each expert

| Expert | No influence (NI) | | | Low influence (L) | | | Medium influence (M) | | | High influence (H) | | | Extremely high influence (EH) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | L | M | U | L | M | U | L | M | U | L | M | U | L | M | U |
| $EXP_1$ | 0 | 0 | 0 | 0 | 10 | 20 | 20 | 40 | 60 | 60 | 70 | 80 | 80 | 90 | 100 |
| $EXP_2$ | 0 | 0 | 0 | 0 | 15 | 30 | 20 | 35 | 50 | 50 | 60 | 70 | 70 | 85 | 100 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| $EXP_{33}$ | 0 | 5 | 10 | 10 | 20 | 30 | 30 | 40 | 50 | 50 | 60 | 70 | 70 | 85 | 100 |

### Step 2: Conduct a pretest to finalize survey questionnaire/distribute and collect survey response

Based on the literature review, we select four dimensions and 16 criteria for a preliminary test. We conduct the pre-test with a panel of experts to determine the suitability of the pre-determined dimensions and criteria. The outcome is that all the experts agree on those dimensions and criteria. Then we finalize the survey questionnaires.

We distribute the pairwise comparison survey questionnaires to 33 experts in person. Each expert spends at least an hour answering the survey questionnaires. We first ask each expert to confirm his or her personalized semantic scale before diving into the survey questions. Then, the experts are requested to indicate the degree of influence among the four dimensions and the degree of influence among the criteria within each dimension on a Likert scale of five. Finally, we collect the survey questionnaires from all 33 experts. The response rate is 100%.

### Step 3: Encode survey data

We initially obtain the expert's opinions using the personalized semantic scale with (1) no influence (NI), (2) low influence (L), (3) medium influence (M), (4) high influence (H), and (5) extremely high influence (EHI) in step 1. We then encode and convert the qualitative and quantitative data into three levels. Finally, we identify the upper, medium, and lower boundaries of each expert in an aim to aggregate the export opinions within a wider collective range.

### Step 4: Defuzzify the fuzzy numbers

We apply the center-of-gravity method described by Roychowdhury and Pedrycz (2001) to defuzzify the triangular fuzzy numbers. Thus, we convert the triangular fuzzy numbers to crisp values. Table 4 shows the conversion from the original semantics to fuzzy semantics, and then to crip values.

Table 4. Conversion from fuzzy semantics to crisp value

| Expert | Original semantics | | | | | Fuzzy semantics | | | | | Crisp value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $EXP_1$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
| | $D_1$ | | EH | M | H | $D_1$ | | (80, 90, 100) | (20, 40, 60) | (60, 70, 80) | $D_1$ | 0 | 90 | 40 | 70 |
| | $D_2$ | H | | H | M | $D_2$ | (60, 70, 80) | | (60, 70, 80) | (20, 40, 60) | $D_2$ | 70 | 0 | 70 | 40 |
| | $D_3$ | H | H | | M | $D_3$ | (60, 70, 80) | (60, 70, 80) | | (20, 40, 60) | $D_3$ | 70 | 70 | 0 | 40 |
| | $D_4$ | M | H | H | | $D_4$ | (20, 40, 60) | (60, 70, 80) | (60, 70, 80) | | $D_4$ | 40 | 70 | 70 | 0 |

*End of Table 4*

| Expert | Original semantics | | | | | Fuzzy semantics | | | | | Crisp value | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $EXP_2$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
| | $D_1$ | | H | H | M | $D_1$ | | (50, 60, 70) | (50, 60, 70) | (20, 35, 50) | $D_1$ | 0 | 60 | 60 | 35 |
| | $D_2$ | H | | H | H | $D_2$ | (50, 60, 70) | | (50, 60, 70) | (50, 60, 70) | $D_2$ | 60 | 0 | 60 | 60 |
| | $D_3$ | H | H | | EH | $D_3$ | (50, 60, 70) | (50, 60, 70) | | (70, 85, 100) | $D_3$ | 60 | 60 | 0 | 85 |
| | $D_4$ | H | M | H | | $D_4$ | (50, 60, 70) | (20, 35, 50) | (50, 60, 70) | | $D_4$ | 60 | 35 | 60 | 0 |
| ... | | ... | ... | ... | ... | | ... | ... | ... | ... | | ... | ... | ... | ... |
| $EXP_{33}$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ | | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
| | $D_1$ | | M | EH | EH | $D_1$ | | (30, 40, 50) | (70, 85, 100) | (70, 85, 100) | $D_1$ | 0 | 40 | 85 | 85 |
| | $D_2$ | M | | EH | EH | $D_2$ | (30, 40, 50) | | (70, 85, 100) | (70, 85, 100) | $D_2$ | 40 | 0 | 85 | 85 |
| | $D_3$ | EH | EH | | L | $D_3$ | (70, 85, 100) | (70, 85, 100) | | (10, 20, 30) | $D_3$ | 85 | 85 | 0 | 20 |
| | $D_4$ | EH | EH | M | | $D_4$ | (70, 85, 100) | (70, 85, 100) | (30, 40, 50) | | $D_4$ | 85 | 85 | 40 | 0 |

### Step 5: Perform consensus test

We perform a consensus test among the experts (Qu et al., 2019). The results of the consensus test confirm whether the overall survey responses are valid. We apply a threshold value of 5% to represent a 95% confidence level. Therefore, the result of the consensus test being 5% or lower (representing a confidence level equal to or greater than 95%) is acceptable, indicating the overall stability of the system. Table 5 exhibits the results of the consensus test.

**Table 5.** Results of the consensus test

| Dimension | Consensus test | Confidence level | Results |
|---|---|---|---|
| All dimensions | 0.85% | 99.15% | Valid |
| Financial indicator | 0.06% | 99.14% | Valid |
| Technical indicator | 0.21% | 99.79% | Valid |
| Investor sentiment | 0.22% | 99.78% | Valid |
| Offering condition | 0.30% | 99.70% | Valid |

#### *3.3.2. Stage 2: DEMATEL method*

### Step 1: Build the initial direct influence-relation matrix ***A***

We establish the direct relation matrix ***A*** through a pairwise comparison. This matrix is an n×n nonnegative matrix. Thus, the initial direct influence-relation matrix ***A*** can be obtained from the survey responses using Eq. (2):

$$\boldsymbol{A} = \left[a_{ij}\right] = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \cdots & & \cdots & & \cdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \cdots & & \cdots & & \cdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix}_{n\times n} . \quad (2)$$

### Step 2: Normalize the initial direct influence-relation matrix *A*

We normalize the initial direct influence-relation matrix A using Eqs (3) and (4) to obtain direct influence-relation matrix ***X***.

$$\boldsymbol{X} = m\boldsymbol{A} = \left[x_{ij}\right] = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \cdots & & \cdots & & \cdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \cdots & & \cdots & & \cdots \\ x_{n1} & \cdots & x_{nj} & \cdots & x_{nn} \end{bmatrix}_{n\times n} ; \quad (3)$$

$$m = \min\left\{1/\max_i \sum_{j=1}^{n} a_{ij}, 1/\max_j \sum_{i=1}^{n} a_{ij}\right\}, \; i, j \in \{1,2,\ldots,n\} \quad (4)$$

### Step 3: Construct the total influence-relation matrix *T*

We construct the total influence-relation matrix ***T*** using Eqs. (5) and (6).

$$\boldsymbol{T} = \boldsymbol{X} + \boldsymbol{X}^2 + \boldsymbol{X}^3 + \ldots + \boldsymbol{X}^k = \boldsymbol{X}(\boldsymbol{I} + \boldsymbol{X} + \boldsymbol{X}^2 + \ldots + \boldsymbol{X}^{k-1})[(\boldsymbol{I} - \boldsymbol{X})(\boldsymbol{I} - \boldsymbol{X})^{-1}] = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X}^k)(\boldsymbol{I} - \boldsymbol{X})^{-1}; \quad (5)$$

$$\boldsymbol{T} = \boldsymbol{X}(\boldsymbol{I} - \boldsymbol{X})^{-1}, \text{ when } k \to \infty, \boldsymbol{X}^k = \left[0\right]_{n\times n} \quad (6)$$

### Step 4: Construct Influential Relationship Map

We compute the sum of each row "***r***" in the total influence-relation matrix ***T*** using Eq. (7). The sum of each row "***r***" represents the total effects (both direct and indirect) of a dimension/criterion given to all other dimensions/criteria.

$$\boldsymbol{r} = (r_1, \ldots, r_i, \ldots, r_n)' = \left[t_i\right]_{n\times 1} = \left[\sum_{j=1}^{n} t_{ij}\right]_{n\times 1} . \quad (7)$$

We compute the sum of each column "***d***" in the total influence-relation matrix ***T*** using Eq. (8). The sum of each column "***d***" indicates the total effects of a dimension/criterion received from all other dimensions/criteria.

$$\boldsymbol{d} = (d_1, \ldots, d_i, \ldots, d_n)' = \left[t_j\right]_{n\times 1} = \left[\sum_{i=1}^{n} t_{ij}\right]'_{n\times 1} . \quad (8)$$

The term $g_i$ is derived from "$r_i$+$d_i$", which represents the total influences given and received by a particular dimension or criterion *i*. The value of ***g*** indicates the degree of importance (centrality) of that dimension or criterion *i* plays in the network. The calculation of $g_i$ is expressed in Eq. (9).

$$\boldsymbol{g} = g_i = r_i + d_i. \quad (9)$$

Another term, $u_i$ is derived from "$r_i$-$d_i$", which represents the difference between the total influence given and received by a particular dimension or criterion $i$. A positive value of $u_i$ means that this particular dimension or criterion is a net giver or a cause. A negative value of $u_i$ means that this particular dimension or criterion is a net receiver or an effect. The calculation of $u_i$ is expressed in Eq. (10).

$$\boldsymbol{u} = u_i = r_i - d_i. \tag{10}$$

We derive the influence of each dimension and criterion from the total influence-relation matrix $\boldsymbol{T}$. Based on $g_i$ and $u_i$, we can depict INRM to indicate the direction and degree of influence of each dimension and criterion.

## 4. Empirical results and discussions

This study uses the fuzzy-DEMATEL method to identify the dimensions and criteria influencing shipping FPOs.

### 4.1. Results

We establish the initial direct influence-relation matrix $\boldsymbol{A}$ and total influence-relation matrix $\boldsymbol{T}$. Table 6 presents the initial direct influence-relation matrix $\boldsymbol{A}$ and total influence-relation matrix $\boldsymbol{T}$ for the four dimensions (financial indicator, technical indicator, investor sentiment, and offering condition).

**Table 6.** The initial direct influence-relation matrix $\boldsymbol{A}$ and total influence-relation matrix $\boldsymbol{T}$ for the four dimensions

| $\boldsymbol{A}$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ | $\boldsymbol{T}$ | $D_1$ | $D_2$ | $D_3$ | $D_4$ |
|---|---|---|---|---|---|---|---|---|---|
| $D_1$ | 0 | 58.687 | 66.111 | 68.687 | $D_1$ | 0 | 2.458 | 2.708 | 2.475 |
| $D_2$ | 53.99 | 0 | 66.111 | 55.96 | $D_2$ | 2.238 | 0 | 2.523 | 2.269 |
| $D_3$ | 47.828 | 54.192 | 0 | 48.889 | $D_3$ | 1.996 | 2.049 | 0 | 2.022 |
| $D_4$ | 68.838 | 61.263 | 65.354 | 0 | $D_4$ | 2.465 | 2.483 | 2.726 | 0 |

Table 7 shows the initial direct influence-relation matrix $\boldsymbol{A}$ and total influence-relation matrix $\boldsymbol{T}$ for the four criteria ($C_{11}$ P/E ratio, $C_{12}$ P/B ratio, $C_{13}$ ROE, $C_{14}$ EPS) within the dimension of financial indicator ($D_1$).

**Table 7.** The initial direct influence-relation matrix $\boldsymbol{A}$ and total influence-relation matrix $\boldsymbol{T}$ for the four criteria ($C_{11}$–$C_{14}$)

| $\boldsymbol{A}$ | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ | $\boldsymbol{T}$ | $C_{11}$ | $C_{12}$ | $C_{13}$ | $C_{14}$ |
|---|---|---|---|---|---|---|---|---|---|
| $C_{11}$ | 0 | 59.747 | 61.793 | 65.202 | $C_{11}$ | 0 | 4.393 | 4.501 | 4.541 |
| $C_{12}$ | 57.626 | 0 | 57.475 | 59.52 | $C_{12}$ | 4.271 | 0 | 4.272 | 4.307 |
| $C_{13}$ | 61.414 | 57.323 | 0 | 62.475 | $C_{13}$ | 4.402 | 4.291 | 0 | 4.436 |
| $C_{14}$ | 66.263 | 62.626 | 66.111 | 0 | $C_{14}$ | 4.651 | 4.537 | 4.652 | 0 |

Table 8 includes the initial direct influence-relation matrix ***A*** and total influence-relation matrix ***T*** for the four criteria ($C_{21}$ KD indicator, $C_{22}$ RSI, $C_{23}$ BIAS, $C_{24}$ MACD) within the dimension of technical indicator ($D_2$).

**Table 8.** The initial direct influence-relation matrix ***A*** and total influence-relation matrix ***T*** for the four criteria ($C_{21}$–$C_{24}$)

| ***A*** | $C_{21}$ | $C_{22}$ | $C_{23}$ | $C_{24}$ | ***T*** | $C_{21}$ | $C_{22}$ | $C_{23}$ | $C_{24}$ |
|---|---|---|---|---|---|---|---|---|---|
| $C_{21}$ | 0 | 59.141 | 56.111 | 57.626 | $C_{21}$ | 0 | 6.56 | 6.283 | 6.273 |
| $C_{22}$ | 58.005 | 0 | 59.444 | 53.46 | $C_{22}$ | 6.325 | 0 | 6.247 | 6.213 |
| $C_{23}$ | 58.384 | 61.96 | 0 | 56.566 | $C_{23}$ | 6.457 | 6.652 | 0 | 6.352 |
| $C_{24}$ | 57.747 | 57.9259 | 52.399 | 0 | $C_{24}$ | 6.15 | 6.338 | 6.062 | 0 |

Table 9 exhibits the direct influence-relation matrix ***A*** and total influence-relation matrix ***T*** for the criteria $C_{31}$ to $C_{34}$ ($C_{31}$ Momentum Index, $C_{32}$ Reference Point Effect, $C_{33}$ Volume, $C_{34}$ Turnover Rate) within the third dimension of investor sentiment ($D_3$).

**Table 9.** The initial direct influence-relation matrix ***A*** and total influence-relation matrix ***T*** for the four criteria ($C_{31}$ – $C_{34}$)

| ***A*** | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{34}$ | ***T*** | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{34}$ |
|---|---|---|---|---|---|---|---|---|---|
| $C_{31}$ | 0 | 59.747 | 58.232 | 61.263 | $C_{31}$ | 0 | 7.35 | 7.161 | 7.12 |
| $C_{32}$ | 57.854 | 0 | 57.626 | 52.626 | $C_{32}$ | 6.699 | 0 | 6.831 | 6.767 |
| $C_{33}$ | 56.717 | 61.869 | 0 | 60.96 | $C_{33}$ | 7.023 | 7.363 | 0 | 7.125 |
| $C_{34}$ | 57.096 | 60.96 | 60.505 | 0 | $C_{34}$ | 6.997 | 7.332 | 7.146 | 0 |

Table 10 includes the direct influence-relation matrix ***A*** and total influence-relation matrix ***T*** for the criteria $C_{41}$ to $C_{44}$ ($C_{41}$ prospective value, $C_{42}$ price discount, $C_{43}$ offer size, $C_{44}$ lock-in period) within the fourth dimension of offering condition ($D_4$).

**Table 10.** The initial direct influence-relation matrix ***A*** and total influence-relation matrix ***T*** for the four criteria ($C_{41}$–$C_{44}$)

| ***A*** | $C_{41}$ | $C_{42}$ | $C_{43}$ | $C_{44}$ | ***T*** | $C_{41}$ | $C_{42}$ | $C_{43}$ | $C_{44}$ |
|---|---|---|---|---|---|---|---|---|---|
| $C_{41}$ | 0 | 63.99 | 63.687 | 61.263 | $C_{41}$ | 0 | 6.836 | 6.799 | 6.73 |
| $C_{42}$ | 61.49 | 0 | 59.899 | 60.505 | $C_{42}$ | 6.571 | 0 | 6.605 | 6.547 |
| $C_{43}$ | 56.566 | 58.232 | 0 | 58.535 | $C_{43}$ | 6.326 | 6.403 | 0 | 6.312 |
| $C_{44}$ | 63.081 | 61.717 | 58.99 | 0 | $C_{44}$ | 6.628 | 6.699 | 6.654 | 0 |

We compute the value of "***g***", which indicates the degree of total influence received and given by each dimension and criterion. A higher value of "***g***" means that a particular dimension or criterion is more influential than others. Thus, the highest value of "***g***" suggests that this dimension or criterion plays a central role in the network.

Conversely, the value of "***u***" represents net influence, indicating whether this particular dimension or criterion is a cause or effect in the network. When the value of "***u***" is greater than zero, this criterion is a cause. When the value of "***u***" falls below zero, this criterion is an effect. As Table 11 shows the values of "***g***" and "***u***" derived from the total influence-relation matrix ***T***.

**Table 11.** Total influence "***g***" and net influence "***u***" of four dimensions and 16 criteria

| Dimension/criterion | *r* | *d* | *g* | *u* |
|---|---|---|---|---|
| Financial indicator ($D_1$) | 9.831 | 8.889 | 18.720 | 0.942 |
| P/E Ratio ($C_{11}$) | 17.693 | 17.583 | 35.276 | 0.111 |
| P/B Ratio ($C_{12}$) | 16.798 | 17.169 | 33.966 | −0.371 |
| ROE ($C_{13}$) | 17.293 | 17.589 | 34.882 | −0.295 |
| EPS ($C_{14}$) | 18.270 | 17.715 | 35.985 | 0.555 |
| Technical indicator ($D_2$) | 9.091 | 9.050 | 18.141 | 0.041 |
| KD indicator ($C_{21}$) | 25.244 | 25.060 | 50.304 | 0.184 |
| RSI ($C_{22}$) | 25.046 | 25.812 | 50.858 | −0.766 |
| BIAS ($C_{23}$) | 25.586 | 24.718 | 50.304 | 0.868 |
| MACD ($C_{24}$) | 24.371 | 24.658 | 49.029 | −0.287 |
| Investor sentiment ($D_3$) | 8.089 | 9.980 | 18.069 | −1.891 |
| Momentum ($C_{31}$) | 28.411 | 27.500 | 55.912 | 0.912 |
| Reference Point ($C_{32}$) | 27.063 | 28.811 | 55.874 | −1.748 |
| Trading Volume ($C_{33}$) | 28.437 | 28.063 | 56.500 | 0.373 |
| Turnover Rate ($C_{34}$) | 28.323 | 27.860 | 56.183 | 0.463 |
| Offering condition ($D_4$) | 9.909 | 9.001 | 18.910 | 0.908 |
| Prospective Value ($C_{41}$) | 26.872 | 26.033 | 52.906 | 0.839 |
| Price Discount ($C_{42}$) | 26.123 | 26.337 | 52.461 | −0.214 |
| Offer Size ($C_{43}$) | 25.173 | 26.191 | 51.365 | −1.018 |
| Lock-in Period ($C_{44}$) | 26.337 | 25.944 | 52.281 | 0.393 |

Based on the total influence ***g*** and net influence ***u*** of the four dimensions and 16 criteria, we generate INRM as follows.

Figure 4 shows the casual relationship and the influence path among the four dimensions (financial indicator $D_1$, technical indicator $D_2$, investor sentiment $D_3$, offering condition $D_4$). Financial indicator ($D_1$, 0.942) is the primary cause, affecting offering condition, technical indicator, and investor sentiment. Offering condition is the second greatest cause ($D_4$, 0.908) affecting technical indicator and investor sentiment. Technical indicator ($D_2$, 0.041) is a relative smaller cause affecting investor sentiment. In contrast, investor sentiment ($D_3$, –1.891) is the effect in the network.

As to the degree of influence, offering condition has the highest influence ($D_4$, 18.910) to other dimensions, followed by financial indicator ($D_1$, 18.720), technical indicator ($D_2$, 18.141), and investor sentiment ($D_3$, 18.069).

Figure 5 depicts the causal relationship among the four criteria (C11 – C14) within the dimension of financial indicator ($D_1$). Figure 5 reveals that EPS is the primary cause ($C_{14}$, 0.555) affecting P/E ratio, ROE, and P/B ratio. P/E ratio is the secondary cause ($C_{11}$, 0.111) affecting ROE and P/B ratio. Although ROE ($C_{13}$, –0.295) affects P/B ratio, ROE remains as net cause. P/B ratio ($C_{12}$, –0.371) is the cause in the network.

Regarding the level of influence within the dimension of financial indicator ($D_1$). EPS ($C_{14}$, 35.985) has the highest influence, followed by the P/E ratio ($C_{11}$, 35.276), ROE ($C_{13}$, 34.882), and P/B ratio ($C_{12}$, 33.966).

Figure 6 exhibits the causal relationship for the four criteria ($C_{21}$ – $C_{24}$) within the dimension of technical analysis ($D_2$). According to Figure 6, BIAS is the primary cause ($C_{23}$, 0.868) affecting KD indicator, RSI, and MACD. KD indicator is the secondary cause ($C_{21}$, 0.184) affecting RSI and MACD. Although MACD ($C_{24}$, –0.287) influences RSI, MACD is the net cause. Lastly, RSI is the only effect in the network. On the other hand, Figure 6 indicates that RSI ($C_{22}$, 50.858) has the highest influence, followed by the KD indicator ($C_{21}$, 50.304), BIAS ($C_{23}$, 50.304), and MACD ($C_{24}$, 49.029).

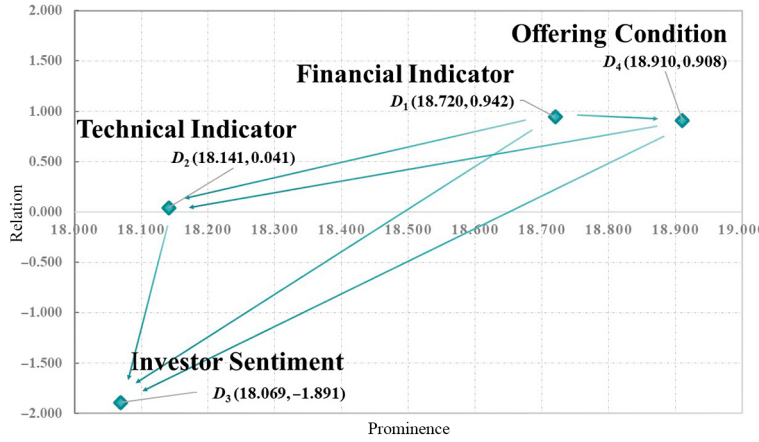


**Figure 4.** INFM of the four dimensions

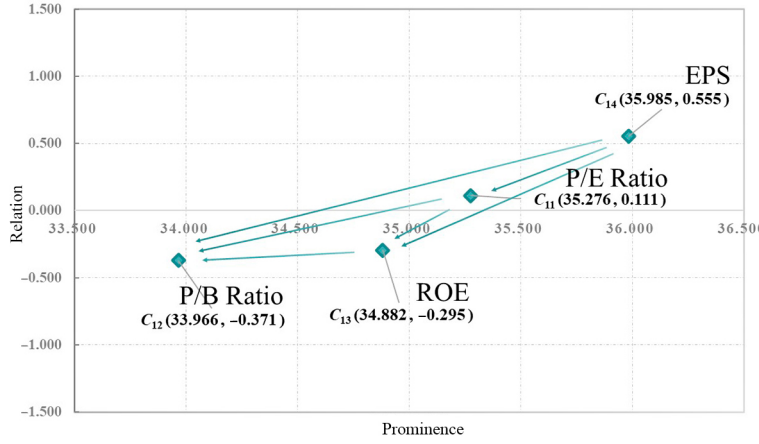


**Figure 5.** INRM of the four criteria within the dimension of financial indicator

Figure 7 illustrates the causal relationship and development path for the four criteria ($C_{31}$ – $C_{34}$) within the dimension of investor sentiment ($C_3$). Based on Figure 7, momentum ($C_{31}$, 0.912) is the primary cause affecting turnover rate, trading volume, and reference point. Turnover rate ($C_{34}$, 00.463) is the secondary cause affecting trading volume and reference point. Trading volume the smallest cause ($C_{33}$, 0.373) only influences reference point. Reference point is the only effect in the network.

Regarding the degree of influence, Figure 7 indicates that trading volume ($C_{33}$, 56.500) has the highest influence, followed by turnover rate ($C_{34}$, 56.183), momentum ($C_{31}$, 55.912), and reference point effect ($C_{32}$, 55.874).

Figure 8 delineates the causal relationship and the path of influence for the four criteria in the dimension of the offering condition ($D_4$). As shown in Figure 8, prospective value ($C_{41}$, 0.839) is the primary cause affecting lock-in period, offer size, price discount, and offer size. Lock-in period ($C_{44}$, 0.393) is the secondary cause affecting price discount and offer size. On the contrary, although price discount ($C_{42}$, –0.214) affects offer size, price discount is the highest net receiver of influence. Offer size ($C_{43}$, –1.108) is also an effect in the network.

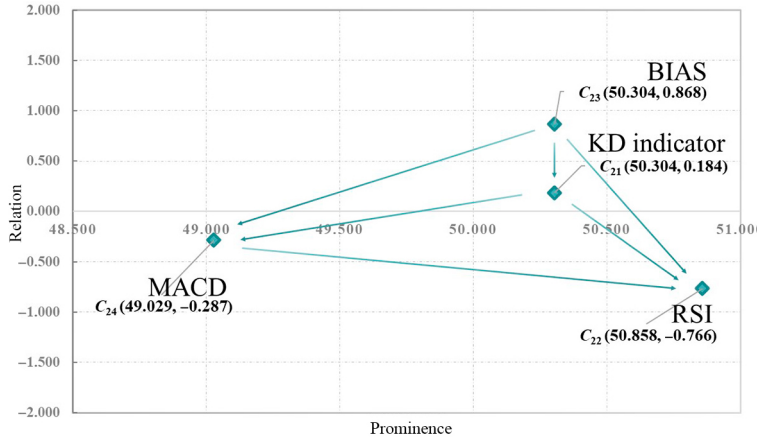


**Figure 6.** INRM of the four criteria within the dimension of technical indicator

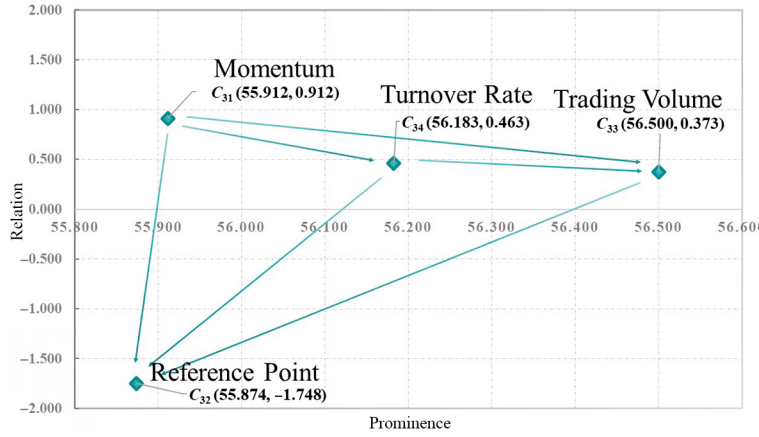


**Figure 7.** INRM of the four criteria within the dimension of technical indicator

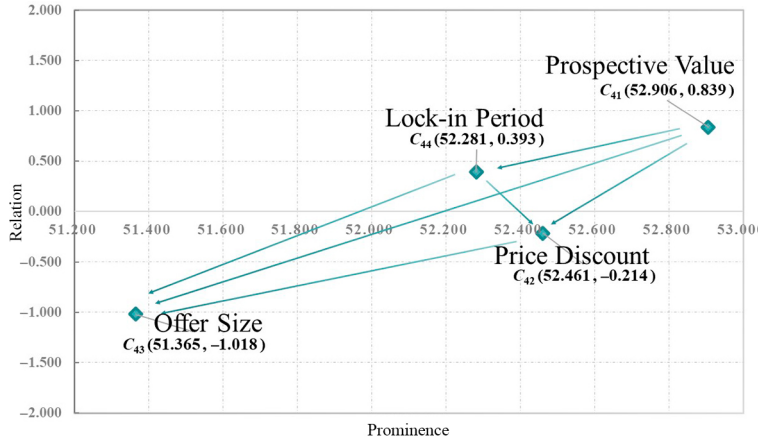


**Figure 8.** INRM of the four criteria within the dimension of technical indicator

With respect to the level of influence, prospective value ($C_{41}$, 52.906) has the highest influence, followed by price discount ($C_{42}$, 52.461), lock-in period ($C_{44}$, 52.281), and offer size ($C_{43}$, 51.365).

Table 12 presents the "***g***" values of the four dimensions and 16 criteria. In addition, it shows the ranking of each dimension and the criterion within each dimension in terms of the degree of influence (centrality).

Table 13 ranking of the four dimensions and 16 criteria based on cause and effect.

**Table 12.** Ranking of the four dimensions and 16 criteria based on the degree of influence

| Dimension | *g* | *g* ranking | Criterion | | *g* | *g* ranking |
|---|---|---|---|---|---|---|
| Financial Indicator ($D_1$) | 18.720 | 2 | $C_{11}$ | P/E ratio | 35.276 | 2 |
| | | | $C_{12}$ | P/B ratio | 33.966 | 4 |
| | | | $C_{13}$ | ROE | 34.882 | 3 |
| | | | $C_{14}$ | EPS | 35.985 | 1 |
| Technical Indicator ($D_2$) | 18.141 | 3 | $C_{21}$ | KD indicator | 50.304 | 2 |
| | | | $C_{22}$ | RSI | 50.858 | 1 |
| | | | $C_{23}$ | Bias | 50.304 | 3 |
| | | | $C_{24}$ | MACD | 49.029 | 4 |
| Investor Sentiment ($D_3$) | 18.069 | 4 | $C_{31}$ | Momentum | 55.912 | 3 |
| | | | $C_{32}$ | Reference Point | 55.874 | 4 |
| | | | $C_{33}$ | Volume | 56.500 | 1 |
| | | | $C_{34}$ | Turnover Rate | 56.183 | 2 |
| Offering condition ($D_4$) | 18.910 | 1 | $C_{41}$ | Prospective Value | 52.906 | 1 |
| | | | $C_{42}$ | Price Discount | 52.461 | 2 |
| | | | $C_{43}$ | Offer Size | 51.365 | 4 |
| | | | $C_{44}$ | Lock-in Period | 52.281 | 3 |

**Table 13.** Exhibits the "***u***" values and rankings. Moreover, it indicates whether each dimension and criterion is a cause or effect

| Dimension | *u* | Cause or effect | Criterion | | *u* | Cause or effect |
|---|---|---|---|---|---|---|
| Financial indicator ($D_1$) | 0.942 | Cause | $C_{11}$ | P/E ratio | 0.111 | Cause |
| | | | $C_{12}$ | P/B ratio | −0.371 | Effect |
| | | | $C_{13}$ | ROE | −0.295 | Effect |
| | | | $C_{14}$ | EPS | 0.555 | Cause |
| Technical indicator ($D_2$) | 0.041 | Cause | $C_{21}$ | KD indicator | 0.184 | Cause |
| | | | $C_{22}$ | RSI | −0.766 | Effect |
| | | | $C_{23}$ | Bias | 0.868 | Cause |
| | | | $C_{24}$ | MACD | −0.287 | Effect |
| Investor sentiment ($D_3$) | −1.891 | Effect | $C_{31}$ | Momentum | 0.912 | Cause |
| | | | $C_{32}$ | Reference Point | −1.748 | Effect |
| | | | $C_{33}$ | Volume | 0.373 | Cause |
| | | | $C_{34}$ | Turnover Rate | 0.463 | Cause |
| Offering condition ($D_4$) | 0.908 | Cause | $C_{41}$ | Prospective Value | 0.839 | Cause |
| | | | $C_{42}$ | Price Discount | −0.214 | Effect |
| | | | $C_{43}$ | Offer Size | −1.018 | Effect |
| | | | $C_{44}$ | Lock-in Period | 0.393 | Cause |

## 4.2. Discussion of results

Based on the empirical results of this study, we find that among the four dimensions (financial indicator, technical indicator, investor sentiment, and offering condition), financial indicator is the primary and offering condition the secondary cause with slight difference. On the other hand, offering condition ($D_4$) has the highest influence ($g_i$ = 18.910) and financial indicator ($D_1$) the second highest influence ($g_i$ = 18.720) with minor difference. Offering condition plays the central role in the inter-related network. Technical indicator is a relatively insignificant cause and investor sentiment the effect. With the two dimensions financial indicator ($D_1$) and offering condition ($D_4$) being the main causes and most influential, shipping companies should focus on them to improve their capital-increase performance during FPO.

Within the dimension of financial indicator ($D_1$), EPS ($C_{34}$) is notonly the primary cause ($g_i$ = 0.555) but also the greatest influencer ($g_i$ = 35.985). Within the dimension of technical indicator ($D_2$), bias is the primary cause ($g_i$ = 0.868) but RSI has the highest influence ($g_i$ = 50.858). Within the dimension of investor sentiment ($D_3$), momentum is the primary cause ($g_i$ =0.912) but trading volume has the highest influence ($g_i$ = 56.520). Within the dimension of offering condition ($D_4$), prospective value is not only the primary cause ($u_i$ = 0.839) but also the most influential criterion ($g_i$ = 52.906).

The findings of this study provide implications for the managers of shipping companies. First, financial indicator is the primary cause and the second most influential dimension in the network, suggesting that investors of shipping companies are rational (Barclay et al., 2021). These investors rely principally on fundamental analysis focusing on the financial performance

of shipping companies rather than technical analysis. In fact, these rational investors are least affected by investor sentiment in the market. Within the dimension of financial indicator, EPS is both the primary cause and the most influential criterion, signifying that investors prefer EPS to ROE and other ratios as the key determinant. Such results correspond to the market-timing theory which proposed that investors expect the currently profitable companies to create their earnings at the same or higher level in the future (Alexandridis et al., 2020; Drobetz et al., 2013). Similarly, shipping companies announcing FPOs offer additional shares to the existing shareholders first, then the public. The existing shareholders are presumed to be more familiar with the past financial performance of the firms. Therefore, the shipping companies could obtain additional capital from the current shareholders more easily. Therefore, financial indicators outweigh technical indicators and investor sentiment (Alexandridis et al., 2018). Furthermore, EPS which represents the profitability of the shipping companies in terms of dividends, plays the most central role in financial evaluation.

Second, offering condition is the second most important cause and the most influential dimension in the network, implying that investors pay more attention not the potential benefits provided by FPO. Furthermore, prospective value is both the primary cause and plays the central role within the dimension of offering condition. Such outcome implies that investors decide to engage in the FPO of the shipping companies because they expect the value of these companies to increase in the future. This finding is consistent with the marketing-timing theory and growth-opportunity theory stating that higher market prospect provides firms with better opportunity to raise funds from the capital market. When shipping companies engage in FPOs and highlight their growth potential in the future, investors are more attracted to exchange their cash for the additional share issued by such firms K. Such results explain why eight shipping companies were able to complete their FPOs from December 2019 to February 2022 when the freight rates increased, and future expectations became more favorable during this period.

Third, the two dimensions of technical indicator and investor sentiment have lower influence on other dimensions. This outcome could be attributed to two reasons. The capital-intensive and highly cyclical shipping industry attracts institutional investors who primarily study the market demand, supply, and components of freight rates to analyze the industry (Stopford, 2009). In addition, a shipping company owns, leases, charters, and operates its vessels and has a consolidated balance sheet (Grammenos, 2010) and shipping finance is a crucial issue across creditors, investors, and financial analysts (Drobetz et al., 2013). Therefore, investors regard financial indicators as more important than technical indicators when evaluating shipping companies (Drobetz et al., 2013; Grammenos & Papapostolou, 2012).

Fourth, the shipping companies can focus on improving EPS, which would positively influence the overall profitability. The enhanced profitability would affect offering condition, technical indicator, and lastly investor sentiment. The shipping companies are recommended to emphasize EPS and prospective value to potential FPO investors by raising their awareness of the ways in which the corporate managers have sustained profits in the past and strive to create greater value for investors.

The major difference between the current study and the literature is described below. Previous studies focused on debt financing or IPO of shipping companies while this study discusses subsequent equity offering. With rising interest rate, bank tightening, and the fact that global shipping companies already conducted their IPOs in the 2000s, FPO has become more relevant after 2016. Prior research revealed the most important factors in bank lending and IPOs of shipping companies. Banks were most concerned with the debt-paying ability of the shipping companies represented by leverage ratio and current ratio (Drobetz et al., 2013). Financial institutions also required loan agreements that contained corporate recourse to protect the lenders (Lee & Pak, 2018). On the other hand, previous studies reported that shipping companies decided to launch IPOs in two conditions. The first condition was the high investor sentiment, representing the optimism of the investors toward the equity market (Grammenos & Papapostolou, 2012; Pribor & Lind, 2016). The second attraction to investors occurred when shipping companies released favorable earnings forecasts which boosted IPO prices (Drobetz et al., 2017). In contrast, this study probed into the factors that affect FPO of the shipping industry. The results are different because the past performance of shipping companies is available and future prospect of these firms are more creditable. As a result, the financial indicators derived from financial statements play a crucial role in the minds of the institutional investors who contribute greatly to FPOs. Moreover, the stock offering condition such as future prospective value and lock-in period are critical to existing investors who already gained understanding of the shipping companies. On the contrary, investor sentiment is less important in FPO than it is in IPO. Similarly, technical indicators widely used by financial analysts appear insignificant probably because the existing investors could decide based on the available financial reports.

## 5. Conclusions

The shipping industry requires substantial funds to acquire new and second-hand vessels, repay debt, or provide corporate working capital. The 2008 global financial crisis triggered the shipping companies to raise funds through IPOs rather than from tightened creditors. During 2007 and 2022, shipping companies engaged in share capital increase by cash payments from investors. FPOs provide shipping companies with a stable source of funds. In response, institutional investors add shipping stocks to their portfolios to diversify the systematic risk.

Prior literature rarely discussed the role of FPOs in shipping finance and the ways in which shipping companies raised additional capital through FPOs. This study bridges the research gap. The purpose of this study is to identify the key factors influencing the FPOs of shipping companies from investors' perspectives using the fuzzy-DEMATEL method.

Based on the literature, we develop four dimensions: financial indicator (P/E ratio, P/B ratio, ROE, EPS), technical indicator (KD index, RSI, bias, MACD), investor sentiment (momentum, reference point, trading volume, turnover rate), and offering conditions (prospective value, price discount, offer size, lock-in period). We collect the survey questionnaires from 33 investment experts and analyze the survey data in two stages. During the first stage, we apply the fuzzy method to aggregate the responses and convert fuzzy numbers to crisp values. During the second stage, we employ the DEMATEL method to identify the interrelationships among the dimensions and criteria.

The empirical evidence indicates that financial indicator is the primary and offering condition the secondary cause with slight difference between them. Within the dimension of financial indicator, EPS is the main cause and the most influential criterion. This outcome corresponds to the market-timing theory and prior studies that claimed investors tend to view favorably the companies that have shown positive financial performance in the past. Moreover, the investors of capital-intensive shipping companies are rational; therefore, they prefer fundamental analysis to technical one.

In addition, offering condition has the highest and financial indicator the second highest influence within the network. Investors are least affected by the prevailing investor sentiment in the market. With the dimension of offering condition, prospective value is the great cause and most important criterion. Such results are consistent with the market-timing theory, growth-opportunity theory, and capital structure irrelevance principle that companies with a greater future market prospect are likely to raise more funds from the equity market.

The findings of this study imply that shipping companies may focus on financial indicator and offering condition. These firms can emphasize their EPS which reflecting past performance and prospective value representing continued sustainability during FPO to attract investors. Positive news about growth in EPS could enhance prospective value perceived by investors, which could lead to favorable technical indicators and optimistic investor sentiment. Furthermore, shipping companies can strengthen their EPS to improve their overall profitability, which would positively influence offering condition.

Prior literature revealed the factors affecting debt financing and IPOs of shipping companies. This paper adds a new layer of information to the literature with the significant factors considered by the institutional investors in FPOs of shipping industry which has become more critical with bank tightening. The key findings of this study benefit shipping companies when engaging in share capital increase with cash from investors. The understanding of factors influencing FPOs could assist the managers of these companies in formulating strategies to achieve their financing objectives.

This paper is original in three ways. First, this paper discusses the key issue of raising funds for shipping companies through follow-on offerings or capital increases. This research identifies the ways in which shipping companies may attract funds from the perspective of experienced investors who determine the survey questions using a pilot test. Each investment expert from the securities company has at least ten years of experience in evaluating stock performance or helping firms list their shares; therefore, these experts tend to provide objective views on what investors consider in stock selection. We also carefully design a personalized measurement scale for each survey participant to avoid confusion in individual language expressions. Second, the four criteria (financial indicators, technical indicators, investor sentiment, and offering condition) confirmed by the investment experts have not appeared simultaneously in any other article. This study is relevant in the field of shipping finance because the four criteria highly reflect the factors considered by individual and institutional investors in the real world. Third, this study identifies not only the most influential criteria but also the cause-and-effect relationships among them. Consequently, the improvement in the causal criteria is likely to enhance the affected criteria. Based on the results of this study, suggestions are provided to the shipping companies to focus on financial indicators and follow-on equity offering conditions rather than on technical indicators and investor sentiment.

This study is limited mainly by the investment experts who could be located during the time of the survey. Future research may remove beyond public equity offering and examine the factors affecting private placements of shipping stocks. Moreover, future studies could involve investment experts from both the developed and emerging markets to provide a comprehensive perspective.

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## Author contributions

Arthur J. Lin conceived the study and was responsible for overall analysis. Sun-Weng Huang was responsible for data collection and analysis. Hai-Yen Chang wrote and edited the article. Jiuh-Biing Sheu was responsible for data interpretation. Gwo-Hshiung Tzeng was responsible for designing the methodology.

## Disclosure statement

Authors do not have any competing financial, professional, or personal interests from other parties.

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