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Reaserch on optimal timing of vessel investment the introduction of CCDG method

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REASERCH ON OPTIMAL TIMING OF VESSEL INVESTMENT

The introduction of CCDG method

By

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DECLARATION

I certify that all the material in this dissertation that is not my own work has been identified, and that no material is included for which a degree has previously been conferred on me.

The contents of this dissertation reflect my own personal views and are not necessarily endorsed by the University.

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ABSTRACT

Title of Dissertation: **Research on Optimal Timing of Vessel Investment**
- **The Introduction of CCDG Method**

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When it comes to the study on optimal vessel investment timing, lots of research were conducted by many scholars in the past. However, we often time find it difficult to directly rely on those findings to give us an explicit answer on investment decisions, as most of the model built in the past are just not comprehensive enough to take the consideration of all aspect of factors that influence the market fluctuation. Lacking systematic relationships between the findings from different aspects, makes it impossible for us to utilize those findings collectively and make vessel investment decisions based on them.

Under the belief of the power of big data and machine learning, a new research direction will be proposed in this dissertation. The CCDG (continuous collective data grouping) method has the potential to quantify and assemble most of the research findings from the past and convert the result of those findings into a quantified, measurable format. By doing so, it brings the benefit of allowing many scholars in this field to contribute to this subject collectively under a same measurement standard that is meticulously designed. Ultimately, to yield a single output as a comprehensive result to guide our investment decisions. Since the CCDG method is a completely new research concept, some detailed approaching strategies will require more in-depth future investigation, even including the feasibility investigation of this method in general. The goal for this dissertation is not to prove the necessity or the superiority of the CCDG method, but to propose a new concept that has the potential to change how we think about vessel investment in the future.

Keywords: Artificial intelligence, big data, prediction, forecasting, CCDG.

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1. Background

Today's world is a fast-changing place, so as the maritime shipping industry. As the maritime shipping industry continue to grow, ship investment as one of the main activities in maritime shipping industry is undoubtably crucial. A good investment decision can boost a company's ability to profit, and a poor one can bring some undesired fanatical burden. The question of "Is this a good time to invest?" has always been a popular subject that is widely studied and disgusted by numerous experts in this field. As many scholars have investigated and discussed this topic in their research, the shipping market is known to have large degree of periodicity, fluctuation, and uncertainty, therefore difficult to predict. However, with the kind of technology and software advancement that are available to use today, and under the eager desire to get an explicit and executable answer to this question, the author believes that it is worth-while to attempt approaching this repeatedly studied topic in a totally different way.

To provide an explicit and executable guidance that is well informed and reliable for an investor to follow when it comes to vessel investment decisions, we need to assemble and take advantage of all the research findings discovered in the past, figure out a way to use them in a comprehensive and collective manner, and to hopeful generate an outcome that is rational, reliable, and more importantly, executable when making investment decisions.

2. Current Existing Research

2.1. Literature review

Wu (2019) states that the scalation in shipping market is closely related to global economy, however the cycle may not be in phase. For dry bulk, despite the seasonal fluctuation, the big fluctuation cycle usually ranges between 4-5 years, or even 7-10 years sometimes. Also, the cycle can be quite different for each type of vessel, for dry bulks for example, those ship has significantly longer service life comparing to other types of ships. And dry bulk market sector has generally less barriers to get into. Wu Yijie also states that during the beginning of post crises period, secondhand vessel will be the limited resources, due to shrined new building order and many scraping

orders. When average deadweight ton yield index increases, this indicates an upcoming market trend, investment is encouraged, vice versa. With the impact of the 2008 financial crisis, the continuous development of the world economy, global trade and the constant proposal of new shipping supportive politics, the old rules of the dry bulk shipping market have gradually changed. Those periotic fluctuation in the market that are used to be so significant and obvious for long time, are not as dramatic in the post-crisis period anymore. As a result, many relatively “well established” analysis (analysis that were believed to be comprehensive and reliable at the time) and volatility research on dry bulk shipping market are no longer applicable in the post-financial crisis period.

Taking the 2008 financial crisis as the node and the shipping cycle theory as the classification standard. The time span of the dry bulk shipping market in the past 20 years were divided into five different stages, which are: the trough period before the crisis, the recovery period before the crisis, the peak period before the crisis, the decline period before the crisis and the trough period after the crisis. For each stage, Wu used the co-integration test and Granger causality test in the time series method to verify the co-integration relationship and mutual influence relationship among the three variables of freight price, new ship price and second-hand ship price in the shipping market in each stage. Based on this strategy, Wu also uses GARCH model to calculate the fluctuation parameters of freight rates and second-hand ship prices in the trough and peak periods respectively, and built a foundation for later use.

Through his research, Wu had three findings. First, the variable BDI, SHP and NBP can undergo exam as an integral in each cycle stage. Second, In the conclusion of the co-integration test, there is only a unique co-integration relationship between the three variables in the trough period and the peak period, and the lag period of the co-integration relationship is 2 months. However, in the recovery period, the co-integration relationship is diversified. In the decline period, the co-integration relationship is proved not to exist between the three variables. Third, In the Granger causality test, the interaction between freight and second-hand ship prices in the trough period before the crisis and the peak period is completely opposite. Meaning that in the pre-crisis trough, the second-hand ship price market will affect the freight market, and in the pre-crisis peak, the freight price is what causes the result of Granger causality test of the second-hand ship; There are many similarities between

the inspection results of the trough period before the crisis and the trough period after the crisis, including that the second-hand ship price in both periods will directly affect the new shipbuilding price and freight rate, but there is no significant interaction between the newly built ship price and freight rate. This also reflects the fact that, despite the current financial crisis and the prolonged period of the trough, most of the characteristics of the trough have not changed. On the other hand, the relationship between the second-hand ship price and the other two variables is also different in those two periods. In the trough period before the crisis, the impact only goes one-way, only secondhand ship price will affect the price of new production of ship and the freight rate fluctuations. The trough after the crisis, the impact change become a two-way influence. That means the price of the newbuilding ship and the freight rate, in turn, will directly affect the fluctuation of secondhand ship price. Although a global event like the 2008 financial crisis can interrupt the trend of normal market fluctuation, or even cause the periodical trading activity to stall in some cases, fluctuation in a different time span and different magnitude can still be found during post-crisis period.

Wang (2004) states that Ship investment is a capital-intensive investment. It is a very important investment activity for shipping companies. The capital cost of ships can account for more than 30% of the total cost of ships. Therefore, the timing of ship investment is very important. To a large extent, it determines the economic benefits of the ship, thereby affecting the cash flow and income of the entire fleet. Regardless of whether it is a new building or the purchase of a second-hand ship, the appropriate time should be selected and operated to reduce the capital cost of the ship, so that the fleet can be lightly loaded. Wang also analyzed the factors affecting the price of new ships, factors affecting the price of second-hand ships, and factors affecting the price of scrap steel ships. Furthermore, Wang used cost pricing, cost-profit pricing, contribution pricing, to determine the price of new ships. By using analogy pricing method, depreciation pricing method, and present value pricing method to determine the price of second-hand ships; use itemized pricing method and tonnage conversion pricing method to determine the price of scrap ships. The time series analysis of the price index of second-hand bulk carriers of 5 years old is carried out in Wang's dissertation, and the law of price changes was found, including long-term trends, seasonal changes, cycles, etc., and finally by comparing the law of cycle changes in

the shipping market, Wang concluded How to choose the timing of ship investment. One thing worth pointing out is that Wang attempted to establish simultaneous equations that takes the consideration of factors like international economy, global trade, shipping market, and ship building efficiency etc. to better model the vessel trading market. (He explained this incentive at the end of his dissertation) However, that was not put into actual research due to limited time and knowledge, as Wang humbly explained. What is interesting is that Wang had this attempt in 2004, even before the 2008 financial crisis when he published his dissertation. The shipping market back then was a very different environment comparing to the market today in 2021. The creation for a comprehensive market model was wanted already. Similar to the proposal this dissertation attempt to make, perfecting such comprehensive model is not an easy task. But with all the new technology and computer software advancement, along with the development of many new studies like machine learning, hopefully such demand can be soon fulfilled.

Huang (2019) points out that Ship investment is an important part of the daily operation and management of shipping companies. It has critical strategic significance. Container ships, as the main ship in maritime trade today, are also determined by their large investment capital, long payback period and high risk. There is a lot of complexity and uncertainty when investing in this kind of project. Huang also did a cost-benefit analysis of the 19,000TEU container ship project that Company A would intend to invest in to determines the cash flow distribution and static and dynamic investment payback periods of the project. Based on the analysis of the traditional influencing factors of shipping, Huang mainly selects the export voyage revenue and oil price as the key influencing factors for sensitivity analysis. It is found that the profit potential of the project of investing a 19,000TEU container vessel is highly sensitive to the export voyage revenue, while the sensitivity to the change of oil price seems moderate. In addition, a simple analysis of financing risk, interest rate risk and exchange rate risk show that the potential risks of the project being unprofitable are controllable, and the project itself has a strong risk resistance. What is research implying is that investing a larger vessel when the market is nor suffering from a global crisis, is generally a viable decision.

Kuang Haibo and Feng Wenwen in their research in 2018 performed an analysis based on the uncertainty risk of crude oil freight index fluctuations. Kuang and Feng took crude oil transportation companies investing in giant crude oil tankers as an example, with maximum investment income expectations as the main optimization goal, a tanker optimal investment decision model based on real option theory was established. The theory utilized the operation parameters of a VLCC from Dalian to West Africa as study sample, performed a verification analysis. The results show that the fluctuation of crude oil freight index has significant uncertainty, and it conforms to the geometric Brownian motion equation in the short term. The uncertainty of freight rate is positively correlated with investment timing, investment scale and investment opportunity value. The greater the uncertainty, the longer the investment waiting time, the larger the investment scale, and the higher the value of the investment opportunity. (Kuang & Feng 2018)

Alizadeh and Nomikos (2007) Investigated the strategies of using the sample of price and chartering rate to establish the relationship of price to earnings ratio. And using this result as an indication when evaluating the timing in sell and purchase market of dry bulk vessel. And they found that the effectiveness of price to earnings ratio based strategy significantly outperforms the buy and hold based strategy in secondhand market of larger ships.

To maximize the profit from a ship investment, Huang (2016) encourage the use of property option to delay the investment execution time, until a clear market trend is revealed. In the field of ship investment, the introduction of real option will make the decision of ship investment more informed and rational. Huang points out that the real option integrates the input and basic rules of the financial market, so it does not need to modify the discount rate according to the decision maker's personal risk preference but adopts the risk-free interest rate to discount. Also, the real option adopts the binary tree pricing model, which can be used to estimate the complex profit and loss of all types of real assets. The price of the real option is calculated through mathematical model of dynamic replication, which can better explain the actual investment behavior. Finally, the use of binary tree model for option pricing, which take into the consideration of the results of various uncertain contingent decisions, and at the same

time retains the form of cash flow discount, which is more practical. However, the application of real option also has some disadvantages. For example, the real option is hidden in the investment project, so it is difficult for decision-makers to find the flexible value and make more informed calculation based on that extra consideration. Secondly, there are many kinds of real options, and their pricing models are complex, which brings some difficulty to the decision makers, as it may not be so straight forward to grasp in every cases. Although there are some disadvantages in the application of real option, the advantage of real option in the field of ship investment is still promising, and the investment evaluation using real option method will likely yield better investment outcomes, when applied professionally.

Yang (2009) Also pointed out that the shipping industry is a capital-intensive service industry with high investment risks. Ship investment is one of the most important aspects of shipping companies' business activities. Being a strategic activity that involves the overall production and operation of shipping companies and modify of the fleet structure and transportation capabilities. Ship investment decisions will directly affect the entire process from the company’s purchase of ships to operation and management and will ultimately affect the future operating benefits of the companies. The traditional ship investment decision-making method based on discounted cash flow analysis (DCF) has defects such as difficulty in selecting discount rates, inaccurate cash flow forecasts, and inability to reflect management flexibility, which can often time cause the underestimation of its option value, therefore, underestimating the true value of ship investment projects, leading to the wrong decisions. Because of the nature of phased characteristics in ship investment decision-making. Yang further investigated the feasibility of more accurate value estimation through the establishment of serial compound option model and some case analysis. And proved the value of the use of compounded real option method.

Ding Tian in her dissertation in 2010 suggest the use of portfolio invest strategy based on seven different types of dry bulk vessel that are representative. Ding established a portfolio model through a selection of vessel combination. Ding also conducted a sensitivity analysis for the sample ship types, calculated the β value of the selected investment portfolio and analyzed the portfolio's ability to resist risks and the degree

of dependence on changes in market. Furthermore, after the investment portfolio plan is determined, the binary tree model was used to analyze the determination of investment timing with the use of real options, so that the income status of investment under different investment timings can be dynamically simulated. Hence, the flexibility value will not be ignored as if it would in traditional investment decision-making methods. Ding believes the outcome of this strategy will help investors make more reasonable investment decisions. Ding (2010).

Yu Wenhao focused on crude oil transportation sector in his dissertation in 2009. The research was based on the tanker investment decision-making for crude oil transportation companies. In the research, Yu summarized some relevant knowledge of crude oil transportation and ship investment decision-making common practices, and then analyzes the supply and demand market of crude oil transportation in China. Based on the status of investment in transport ships, the idea of real option game theory was introduced to analyze the ship investment decision and then explanations were made empirically. In his research, Yu studied the characteristics of marine crude oil transportation and summarized three existing ship investment decision-making methods that are commonly used. Yu believes that the ship investment decision-making is largely affected by the impact of uncertainty and oligopoly in the crude oil transportation market.

Yu utilized the Kalman filter method to predict the crude oil consumption in China, combined with oil production and future crude oil transportation demand in China, and drew a conclusion, claiming that China urgently needs to increase crude oil transportation capacity. Yu then used the real option game theory, to treat the oil tanker investment income problem as a real option problem, and the opportunity value of delayed investment is regarded as the option value as well. The oligopoly competition of two crude oil transportation companies in ship investment was also analyzed using game theory as examples to verify the theoretical model. The investment decision-making method based on real option game theory is a generalization and summary of a way of thinking that actively responds to uncertain factors and monopolistic competitiveness. It enables the flexibility value of decision makers to be reflected and quantified, and theoretically revised the shortcomings and shortcomings of traditional decision-making methods make investment decisions

more realistic and provide decision-makers with reference to market conditions and risks, hence, to be able to evaluate oil tanker investment projects more accurately and make more informed decisions. (Yu, 2009)

Jiang (2008) states that most research on ship investment timing are heavily dependent on the use of traditional regression models, or simultaneous equation models for analysis. However, such technique must be based on a stationary sequence, whereas most economic time series are non-stationary, leading to false modeling and unsatisfied research results. The use of co-integration theory and dynamic modeling methods can avoid such problem. At the same time, the vector error correction model decomposes fluctuations into long-term trends and short-term adjustments, which can well reflect the dynamic fluctuation characteristics of the shipping market. Therefore, the use of cointegration theory to establish a vector error correction model was applied to study the problem above. From the methodologies Jiang applied in his research, 4 conclusions were made. Firstly, the use of cointegration theory can avoid the happening of false regression problem that is commonly found in traditional model, and can better analyze the relationship between various factors in the ship buying and selling market. The time series data such as the second-hand vessel price and freight rate are usually difficult to be described in stationary time series. The traditional modeling methods can result pseudo regression and lead to unsatisfied results. However, the co-integration theory can better handle this problem and accurately reflect the relationship between the variables. Secondly, there is a cointegration relationship between the price of secondhand ship and its related factors. The dry bulk shipping market is a significant sector of the international shipping market, there is a very close relationship between the vessel trading market and other shipping markets. Through the cointegration analysis, it is shown that there is a cointegration relationship between the price of secondhand ships, time charter rate and shipbuilding cost. Thirdly, the vector error correction model of second-hand vessel price can accurately reflect the fluctuation of market vessel price. The Johansen test shows that there is a strong cointegration relationship between the price of secondhand ship and the time charter rates, the price of new ship and the number of new building ship order to fleet size ratio. By establishing a vector error correction model, the fluctuation of secondhand ship price can be divided into two

categories, which are long-term trend and short-term adjustment. By doing so, the fluctuation of secondhand vessel price can be precisely simulated. Forth, the moving average investment timing model of the ship price to freight rate ratio can reflects the fluctuation of the value of second-hand ships very well, and can help enterprises and investors grasp the investment timing reliably. There is a cointegration relationship between the price of second-hand ship and time chartering rates. Similar to the idea of the price earnings ratio in the stock market, along with the use of the moving average method of the ratio of ship price and freight rate, the construction of the investment opportunity model of ship buying and selling can be better realized.
Zhou Weidong claims that the big economic environment has great influence on vessel purchase and sell market, along with the entire maritime transportation market in general. The economic environment plays a big role in the development of international maritime industry. (Zhou, 2003)

Gkochari used the historical dataset of the capsize market development over the period of 2007 to 2013, along with the use of option trading, explained the existence of boom-and-bust cycles in the industry. During the investigation, empirical evidence on the application of the stochastic dynamic competitive equilibrium in the dry bulk shipping market was provided for the very first time. Also, additional insights into the forces that shape certain market regularities was explained as well. Gkochari also suggests that the major driver of construction cascades and recession induced construction booms is the time-to-build delay. (Gkochari, 2015)

Yu Siqing, Chen jinhai and Huang Shunquan established value model follows average price regression, solved investment threshold value and option value. According to their research, as the risk-free interest rate increases, vessel value, investment margin and the value of investment projects will decrease. But the investment duration will become longer. Also, based on the ordering data for container vessels, most of the vessel investment decision occurs during the time when shipping market is prosperous or recovering from a bust. (To a degree, this finding can imply that the market is often time unable to foresee an upcoming rebound and make investment decision at an optimal timing. Because otherwise the investment decision would have been made before a recovery starts.) As a conclusion, their research also points out

that due to the time gap between a new ship being ordered and still the ship being delivered, the current net cash flow should not be used as a consideration factor when madding investment decisions. Instead, the net cash flow during the ship's operation is a better choice to consider when making decisions. Buying a secondhand vessel instead of placing a new building order as a form of investment, often result a better outcome during operation. (Yu.Chen & Huang, 2014)

Beenstock (1985) and Vergottis (1993) came up with a conclusion from their research, believing that the construction cost of a new built vessel does not affect its sell price. And Kavussanos (1997) states that the smaller the vessel, their price are less sensitive to market fluctuation.

Yu Yuqing (2012) utilized the concept of EPS (earing per share) and P/E ratio from stock market to evaluate the relationship between ship price and freight rate. This method indicates how overpriced or underpriced the current ship price is. Yu also states that majority of the scholars agrees that when analyzing the trend from shipping market data, 2008 should be a time node for better data grouping, as many trend models developed prior to 2008 were no longer valid for post 2008 market behavior.

2.2. Room for Improvement

The findings from the research conducted in the past have constructed a solid foundation for how we value an investment opportunity, informed us the varieties of investment strategies that can be applied. And shaped our understanding on the kinds of investigation and experiment have been done in the past by the pioneers in this field. However, for the goal of getting an explicit answer for the question of "is this a good time to invest?", the room for improvement appear obvious.

First, the conclusions from all the research done in the past are scattered, as most of the research projects are specific aspect targeted. Those findings have meaningful academic value, but not so easily to be put into practical use. In other word, those conclusions are all correct in their own way, but together, lack of systematic

relationship with other discovered findings. (This is not a criticism of any kind. Instead, in-depth investigation in a particular area indicates great level of proficiency and usually results better outcome qualities.) To be able to use the findings to make investment decisions, all influencing factors need to be considered as a whole. Lacking that common link makes it difficult for an investor whose seeking vessel investment guidance to benefit much from knowing those information fragments in a practical way. To put it in a simple term, it is nearly impossible to apply those findings collectively to get an explicit confident “Yes” or “No” answer, when it comes to an investment decision. Without a standard scale of measurement that links all the findings from different influencing aspects, conclusions cannot be utilized collectively as a whole to determine our investment decisions.

(For example, the factors and methods used to determine vessel investment decisions suggested by different scholars can be different. Alizadeh and Nomikos (2007) suggests that the price to earnings ratio based model can outperform other types of methods, therefore should be used primarily as the influencing factor to determine the investment decisions. Whereas Ding (2010) suggests the portfolio of different vessel types in a fleet should be the input to use when making vessel investment decisions. As we know that both findings are evidence based and rationally concluded. Now, given the present time if we had a vessel investment opportunity. We ran those two methods with all the data needed and trying to figure out whether we should make this purchase or not. But the results from those two methods came out to be different, which is a totally possible scenario. Meaning that one method suggests that this is a good time to invest, and the other one suggests otherwise. Which one should we follow? This would be an exact problem investors will encounter, when trying to utilize all the findings discovered from the past research individually, without any correlation between the findings from different aspects, and not having each finding being quantified on a same standard.)

Secondly, our world changes every day, so as the maritime industry. An established models that was predicting some past events well, can be obsolete overtime, if the model does not evolve along with the market. Often time, when someone realizes a model is no longer accurately describing the market movement, new model will be created by the new scholar. However, the reality is that no model will be perfect, it

takes time to test the reliability of a model. (Traditionally, a student or a scholar simply will not spend long enough time perfecting an existing model built in the past, as he/she will most likely stop investigating after graduation as we all do, or simply moved on to another project. Till someone decided to create a new model to replace the old ones, and go through all the steps over again trying to make the new model reliable enough for practical use. Overtime, more and more obsolete, or halfway done model will be left on the table for others to read, study, or even trying to use. Although, this is not a criticism, as the value of new research approach sometimes exceeds the value of fixing an old model.) A better way to yield a practical and effective model would be to continue perfecting a proven one that is more comprehensive, instead of keep creating new models based on some particular factors that cannot represent the entirety of the dynamics of the market behaviors. Because at the end of the day, no one knows which model to trust and follow, especially when the outcome produced among them are not consistent.

Third, vagueness or lack of quantification in the conclusion are also the issues that is preventing others from verifying the accuracy of a finding and ultimately benefiting from reading that research in a practical way. The idea from the famous quote “We cannot manage what we cannot measure” from Peter Drucker[1] fit in nicely in this scenario. Although vessel investment timing is undoubtably a complicated problem which involves so many macro and micro economic influencing factors, and coming up with a conclusion that is explicit and measurable for all investment scenarios are not always that feasible. But to use the past findings for investment decisions, a measurable conclusion is a must.

Researching on this topic with more collaboration of join-forces can be a new concept that is worth trying. It would be very beneficial to have a mathematical framework that takes into the consideration of all the discovered findings of factors that affects the future shipping market in appropriately quantified state, and this model will keep evolving as more recent data being fed to it. This way, the model would be most

[1] Peter Ferdinand Drucker was an Austrian American management consultant, educator, and author.

comprehensive and always up to data. Ultimately, it could even be the “golden formula” to apply when investment advice is needed in the future.

3. Introduction of “CCDG” method

Inspired by the attempt that was mentioned in Wang (2004), which was trying to establish a simultaneous equation that includes the influence from additional factors like global economy, world trade, shipping market, shipyard capacity and other less studies factors like economic prosperity index into its market model to reflect the vessel trading dynamic at more comprehensive level. The CCDG method that is proposed in this dissertation have the similar goal, which is to build a model that is comprehensive enough to include most of the proven corelating factors that are discovered in the past research, and yield an output that is more explicit and practical. However, the approach of CCDG method is totally different.

Continuous Collective Data Grouping (CCDG) works in a very simple logic. First, select the factors that is proven to have some degree of impact on future vessel market (initially, we can manually pick out those influencing factors from the findings concluded from past research results. For example, when considering dry bulk vessel investment, the global iron ore price will be one of the influencing factors for optimal investment timing). Since those sampled influencing factors all have different unit of measurement[2], we need to quantify or converting the sampled value of this influencing factor into one common unit of measurement, so that they can be summed. In this case, our common unit of measurement will be a percentage value[3], which indicating the investment decision confidence level as if this particular factor was the only factor that is affecting the market (100 being fully confident to invest, and zero being not confident to invest at all.)

[2] Different influencing factors can have their units in Dollars, tons, TEUs, days, or number of times, and some can be a ratio or an index. Without a common scale of measurement, factors cannot be added to yield one collective result.

[3] Values from each factor can be converted to a common unit of measurement, the investment confidence percentage. Detailed converting strategy will be explained in chapter 4.2.

This percentage value will then get multiplied by a hierarchical multiplier ranging from 0 to 1 based on the degree of relevancy (zero meaning this factor does not affect the market, 1 meaning that the factor is solely or dominantly affecting the market, and any number in between indicates the influencing proportion of this factor). The hierarchical multiplier can be calculated using methods like regression, vector autoregression, and other more advanced cloud-based computing strategy through the use of sufficient historical data. Finally, the weight of each selected factor will be added together to get a total percentage value output, which implies how encouraged the current investment timing is.

Model structure:

$$r_1 * x_1 + r_2 * x_2 + r_3 * x_3 \ldots\ldots = Y$$

Where $r_1 + r_2 + r_3 \ldots\ldots = 1$ and $0 \leq x \leq 100$

r = Hierarchical multiplier for each influencing factor
x = Investment confidence percentage of each factor at given time frame
Y= Summed confidence percentage (this indicates whether to invest or not)

After the model is established, it then needs to be paired with a set of rules that serves as model updating guidance. As mentioned earlier, no model is perfect. That is exactly why the CCDG method will have a well-designed self-adjusting “mechanism” that is performed regularly as a protocol to adjust the x and r value for each chosen factor if needed. Such predetermined process will allow the model to be always up to date, require minimal manpower to perform any maintenance, and near perfect as time progresses.

There are two major advantages when comparing CCDG method with any other market model built in the past.
First, CCDG method is more practical. Instead of considering CCDG as some sort of comprehensive market model, the essence of CCDG method is more like an informed “decision maker”, which will only tell you an explicit[4] answer of either “Yes” or “No”

[4] Although it gives a confidence percentage as an output. It is reasonable to comprehend results above

when facing an investment opportunity. It means that the CCDG method has more practical value, as its output will be not only rational, but also more executable.

Second, continuous updating is feasible. When designing the CCDG method, the author is fully aware that models or methods can be obsolete if not maintained regularly. that is why the CCDG method will come with a predetermined self-updating procedure that need to be periodically performed to adjust the x and r inputs. As a result, the output CCDG method will reflect the influence from most recent events and data.

4. Research Methods and strategy

4.1. Model framework establishment

Quantification and hierarchization of key factors

With no doubt, the process of quantification and hierarchization (which is to determine the x and r value) for each selected key factor are critical for the CCDG method to perform effectively. In fact, being one of the core ingredients of the CCDG method, more future research and investigation are highly recommended. Strategies below have some obvious flaws but can be served as a starting point towards this new research direction.

4.2. Strategy for Quantification

From the findings gathered from the research done in the past, it is known that some factors are proven to have either positive or negative impact on the potential future profitability. For example, Yu Yuqing (2012) used the vessel price to freight rate ratio to mimic the use of P/E ratio[5] that are commonly used in stock market price analysis. This factor indicates how overpriced (or underpriced) the current vessel price is based on its ability to profit. This is undoubtedly an important factor to consider when trying to determine the optimal investment timing. To use the CCDG method, the value of

50% as an “Yes”, and below 50% as a “No”, when applied for decision making.

[5] P/E ratio (Price to earnings ratio) is an indicator that can be easily calculated and commonly used to quickly evaluate the price value of a particular company’s stock.

“P/E ratio” will need be converted to a percentage value indicating the level of investment confidence. For instance, if the current ratio goes to less than 10[6], which is a very low number for P/E Ratio. The vessel price can be considered as underpriced in regarding to the current freight rate, this would be a strong signal for a good investment timing, we can therefore assign 100% to the “x” value. On the other hand, let us say if the ratio value being larger than 130, meaning the vessel market price is highly overpriced for some unknown reason. A confidence level of 0% can be assigned as a threshold value for overpriced situation, assuming this “P/E Ratio” was the only factor that is considered. Based on that scale, the “P/E ratio” value of 60 will result in a confidence level of 50%, and value of 30 means a confidence level of 25%, etc[7]. And those percentage values will be used as the “x” variable in the equation.

By performing this input type conversion process, most of the influencing factor values can be rationally converted into one common unit of measurement.

4.3. Strategy for Hierarchization

The hierarchical multiplier “r” determines the degree of relevancy between each selected factor. Which means, the “r” value of an influencing factor reveals how significant each factor is when it comes to determining the output, without the consideration of this factor’s actual change of value (as that has been included in the previous process of finding the variable “x”). The concept is easy to understand but assigning the appropriate hierarchical multipliers to each factor is not an easy task. There are numerous factors affecting the market behavior, many of them are also affecting other factors as those factors start to change simultaneously, meaning that some variable can be independent variable and dependent variable at the same time. This makes it difficult for us to grasp the real relationship[8] between all the factors.

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[6] 10 is considered as a relatively low value, as the recorded average ratio for S&P500 ranging from 13 to 15.

[7] For better explanation on how the scale is calculated: 60/ (130-10) =0.5 and 30/ (130-10) =0.25

[8] If somehow, the relationships between all the influencing factors are fully understood, it is expected to see that many of the factors that seems to have some impact on the market movements are actually not independent variables in the equitation that’s used to predict the future market. Because those factors can be predicted based on other known relationships and the determine factors of those. For example,

Without a better solution for this task, there are few methods that can be applied to get a starting point on this process. The use of Vector Autoregression (VAR) and Linear regression to capture the relationships between all the influencing factors is one way to approach this problem, but surly not the best way, and the outcome will only generate a conclusion at superficial[9] level (see footnote for explanation). VAR as a type of stochastic process model that is commonly used as a statistical tool to capture the relationships between multiple variables through their sets of equations, certainly will not be the most ideal way to tackle this scenario. However, with sufficient supply of historical trending data of each targeted influencing factors, (which some can be found on published data center like Clarkson Database), some reasonable assumption can be made, and allow the model to be established.

The found x and r value for each influencing factor will then get multiplied to get a share of weight of this influencing factor. Finally, the weight of each influencing factors will be summed up to yield the final confidence percentage as the output Y, which is a value that can be used directly to determine an investment decision. Up till this point, an initial framework of the CCDG model is established, and ready for validation.

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if variable "a" in our equation can be predicted or calculated though knowing its describing function, we will no longer need to consider "a" in the final equation, as "a" is not a real independent variable that is dictating the output. (Although sometimes it may very much seem to be an independent variable, like the periotic change of steel price, or a raise of labor cost in a particular shipyard for instance.)
Once those relationships are understood and "cleaned up", there will be much fewer independent variables left on the table (perhaps less than 10, or even less than 5 variables that are truly the root cause of everything else), this simplified situation will then make this modeling process much more feasible. But before then, the amount of variable and the level of complexity makes this whole puzzle very difficult to solve due to our limited understanding on the dynamics of the market.

[9] The use of VAR (Vector Autoregression) method in this scenario has two endogenous flaws.
First one is that the VAR method require the establishment of the equations to describe the dynamics of each selected influencing factors. This means the historical trending data for each selected factors needs to be described in individual equations beforehand. Here is the problem, consistency of data is needed when building a model for this time-series event. But when sampling the historical data for any influencing factors at reasonably long enough period, consistency almost never exist.
Second one is that the VAR model only takes the consideration of the presented time series data as its input. However, most of those historical data are the result of some other deeper root causes. For example, the change of crude oil price is believed to be one the contributing factor for optimal vessel investment timing. Yet the crude oil price itself is actually a result of many other deeper variables, including the amount of global crude oil reserve, political stability of oil producing nations, change of oil processing efficiency, or even the level of global belief of US dollar hegemony. This means that the change of crude oil price is actually a result, not a cause. By simply sampling the change of crude oil price as the input data in VAR modeling practice will not only unable to provide the final model the ability to foresee the potential rapid change of output due to occurring of some dramatic events, but also will come with large degree of undesirable latency in its prediction.

4.4. Model maintenance

4.4.1. Output accuracy verification

A newly established model may not be accurate enough for practical use. That is why a regularly performed result verification and variable updating process is needed.

One way to verify the reliability of the output is to reference the output with historical real-life data. Vessel investment decisions are constantly being made around the world. Some can overtime prove itself to be an investment at good timing, some are proven to be not so good. Using the CCDG model to simulate the past evens with recorded historical data, and compare the result from the CCDG method with the decisions made in the past in real life, can reveal how well the model's suggested decision align with decisions made in real-life in the past. For example, feeding the CCDG model with all the needed data prior to 2007. If the output shows the confidence level of purchasing a new 11,000 TEU container vessel at 140 million dollars in October of 2007 being above 50%, that will imply that the model was not good enough for practical use. Because looking back, we know the market will crash soon after. Performing this simulation exam at long enough time span with various targeting categories, it would be clear how well the model is predicting with some noticeable consistency.

4.4.2. Collaborative updating protocols

One of the main benefits for establishing the CCDG model is to allow all the scholars in this field to contribute collectively on this subject in a structured manner by converting their findings into one same unit of measurement. This way, we can hopefully end up with one practical output as a collective result, instead of having many scattered information fragments. It is not easy for an investor to benefit much from knowing those information fragments when it comes to decision making, especially if those findings are pointing at different direction. Although it might sound like critical comments on other scholars' research work, it is truly not. The introduction of CCDG method is not to discourage other traditional form of investigation about vessel investment

timing. In fact, the CCDG method is built based on the finding from those past research conclusions. The CCDG method itself does not discover any new findings, but simply a tool that extract the information from past research findings and converting the results into an executable format, to helps the investor make more informed investment decisions. And those influencing factors the CCDG method uses are all need to be gathered from the finding of other scholar's work. The more explicit and accurate the input findings are, the more efficient the CCDG model will be.

The reliability of the model is heavily dependent on continuous improvement, which means the x and r value (x being confidence percentage and r being hierarchical multiplier, as mentioned above) needs to be periodically updated under the guidance of some carefully crafted rules that can be served as a predetermined decision-making instruction when it comes to updating the x and r value. When this rule is developed and proven[10] to be mature enough, and has the versatility to cope with most of the market changing conditions, it can then be used as a protocol to allow modifications to be made to the input variables by any students or scholars in this field. Such join forces with continues collective contribution will allow the model to evolve.

Due to the complexity of such "mechanism", and insufficient personal research skills, the detailed design of variables updating procedures was not attempted in this dissertation research. more in-depth research on detailed design of this passive updating protocols is advised in future investigation. In fact, the variable updating procedure is so information demanding that it could even be a research topic on its own. There are so many aspects that will need to be meticulously evaluated and designed. For example, the number of false predictions that is allowed before executing the updating procedure; how the hierarchical multipliers are re-evaluated for the new updates; when consistent error occurs in the prediction, how to determine which factor's hierarchical multiplier is the one that needs adjustment, and how much to adjust. All those unanswered questions will require lot more effort to be spent on this new

[10] Which can be difficult to prove. this is a defect of this method.

research direction in the future.

It is believed that when enough information is given, the future market behaviors will be more predictable. Maybe it can even be as good as weather forecast someday.

5. Summary

The CCDG method is created under the main goal of creating an intelligent decision making strategy that is not only well informed by including all the influencing factors into its algorithm, but also being able to answer the question of “Is this a good time to invest?” with a simple confidence percentage as its form of output. Which is explicit and executable when facing investment opportunities. In addition, through the application of meticulously designed self-evaluation and self-updating protocols, the CCDG model will be regularly updated to accommodate more recent market chance, and therefore will have a prolonged service life.

Perfecting the CCDG method is a huge project. Technically speaking, the design of CCDG method is unfinished. The process of calculating the “r” value (Hierarchical multiplier) for each influencing factor through regression method was explained but not performed in this dissertation, due to insufficient data support[11]. Neither was a case study conducted, for this same reason. However, being the objective of this ongoing new research project, two things are accomplished though this dissertation. First, A new research direction that is big-data concept based was proposed in this dissertation, for the goal of acquiring an explicit answer in the field of study of optimal vessel investment timing. With the potential practical value that CCDG method could

[11] The attempt to collect time series data of all the influencing factors was not successful. Finding data sets that are reliable and complete enough has always been a problem throughout the research. Some of the time series data found on Clarkson database only have recent few years of record. Considering the amount of data that would needs to be processed through series of regression operation to get a promising result. the plan of conducting a detailed regression operation to determine the “r” values for each influencing factor was abandoned in this dissertation.

offer, research like this one would possibly inspire more scholars to start paying more attention to this new research path, and dive deeper.
Second, the mathematical framework of CCDG model was established and explained in this dissertation. As well as the algorithm on how to convert the sampled values of different influencing factors into an investment confidence percentage as a common standard of measurement for all chosen factors. In addition, a guideline on how to calculate the hierarchical multiplier for each input variable was explained as well, even though the regression operation was not performed due to the amount of data that would need to be properly gathered and processed.

Although the CCDG method may seems to be a very promising solution for vessel investment decisions, it does come with some pitfalls and drawbacks that we need to be aware. During the process of converting sampled values of each factor, errors can be introduced. If the boundary of converting scale is not properly chosen, which there is not a standard instruction procedure on how to do the conversion introduced in this dissertation, the x value may be biased, which obviously will damage the efficiency of this method. Also, the ultimate accuracy heavily relies on how well the self-updating procedure is designed. Due to the sophistication of such predetermined procedure, it is expected that the imperfection in the system may not be easily identified and altered. But overall, the CCDG method, as a new method of approach that extract and utilizes the “big data” already exist in our maritime industry, and under the present era with so much advanced computing capability available, is worth pursuing.

6. Outlook

The CCDG method opens a whole new path for us to discover, but it is also possible that it might lead us to a dead end. During the interview with the former CEO of APL China, When Mr. Zhao was asked for his opinion on new investment assisting strategies like CCDG method, Mr. Zhao replies and states that most of the large container ship company has their own fixed but effective investment strategy now a days. That is to only purchase container vessels that are larger than 20,000TEU

whenever they have a chance to, then putting those newer and larger vessels into longer route liner service, replace and reassign the older and smaller vessels for other shorter route liner service (Hongzhou, 2021). From industry experience perspective, this simple strategy makes perfect sense for large shipping companies. However, this also implies and reminds us of the existence of the gap between the academic world and real-life industry practice. Because obviously, such simple but brilliant strategy did not benefit from utilizing the CCDG method or any other traditional market prediction models, yet proven to be very effective and has been working out great for those companies. Therefore, it is hard to promise the true value of some theoretical advancement before it has been proven in real life application.

But, under the power of big data, there is still a great potential that CCDG styled modeling technique could allow us to discover something that was not possible to be seen using traditional forecasting strategy. One scholar will always have limited expertise, and that is why a new model will never be perfect. The only way to acquire a near perfect model is through continuous collective contribution from many scholars and experts in this field. To do so, we need an inclusive model that converts everyone’s research finding into one same format, and this will allow us to have an output result that is universally explicit, measurable, and more importantly, executable.

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