8-30-2023

Design and implementation of China's refined oil shipping market prosperity index

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DESIGN AND IMPLEMENTATION OF CHINA'S REFINED OIL SHIPPING MARKET PROSPERITY INDEX

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A dissertation submitted to the World Maritime University in partial fulfilment of the requirements for the award of the degree of Master of Science in Maritime Affairs

2023

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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ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to World Maritime University and Dalian Maritime University for offering me the opportunity of participating in the joint MSc programme in Maritime Safety and Environmental Management. I am particularly grateful to the faculties of both institutions, especially Prof. Zhao Jian, for their invaluable guidance and support throughout my academic journey.

My heartfelt appreciation goes to my supervisor, Prof. Liu Zhengjiang, the vice president of Dalian Maritime University, for his expert advice, mentorship, and unwavering encouragement during my dissertation research.

I am also grateful to my company for equipping me with the knowledge that has been crucial for the dissertation. Special thanks to the company's president Mr. Li Junhai, for his mentorship and for sharing his vast experience and wisdom, which has greatly influenced me and my research.

I would like to acknowledge my friend and colleague, Miss Gong Yunchi, for her assistance with the analysis aspects of the dissertation. Her expertise has been indispensable in the completion of this work.

Last but certainly not least, I want to express my profound gratitude to my wife, Sang Jun, and my children, Yang Chenxi and Yang Chenyi, for their constant love and understanding as I pursued my studies. Their support has been the driving force behind my success. I am truly blessed to have them in my life.

ABSTRACT

Title of Dissertation: **Design and Implementation of China's Refined Oil Shipping Market Prosperity Index**

Degree: **Master of Science**

China's refined oil shipping (CROS) market is a niche area that few researchers have studied so far. However, this specific market plays a significant role in China's economy, energy security, and essential livelihood protection. During the last decade, the CROS market experienced a great leap following China's rapid economic growth and increasing demand for energy.

The CROS market is influenced by many factors. The demand side includes China's economic growth, refined oil production, consumption, exports, and shipping volume. The supply side consists of the number and capacity of ships, etc. Other factors include prices and costs. Analysing the economic aspects of this specific shipping sector requires specialised knowledge and extensive data support.

This dissertation seeks to create a prosperity index that can analyse and indicate the state of China's refined oil shipping market by examining its key drivers, assessing its current status, and predicting future market development. This index aims to guide the CROS market towards a healthy development path and assist in decision-making for relevant industry stakeholders.

KEYWORDS: prosperity index, refined oil, shipping, China

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LIST OF ABBREVIATIONS

CIBCR	Centre for International Business Cycle Research
CNOOC	China National Offshore Oil Corporation
CNPC	China National Petroleum Corporation
Sinopec	China Petrochemical Corporation
CROS	China’s Refined Oil Shipping
CI	Composite Index
DI	Diffusion Index
DFMs	Dynamic Factor Models
GDP	Gross Domestic Product
Hengli	Hengli Group
IEI	International Economic Indicator system
IMO	International Maritime Organization
MOT	Ministry of Transport of the People’s Republic of China
MI	Monitoring Index
NBER	National Bureau of Economic Research
ODI	Optimised DI
OECD	Organization for Economic Cooperation and Development
PI	Prosperity Index
PMI	Purchasing Managers' Index
SSI	Shanghai Shipping Index

SIC	State Information Centre
SOEs	State-owned Enterprises
VI	Verification Index
WI	Warning Index
WTO	World Trade Organization
Zhejiang Petrochemical	Zhejiang Petroleum & Chemical Co., Ltd.

CHAPTER 1
INTRODUCTION

1.1 Background

As a crucial player in the global economy, the shipping industry takes up 80% - 90% of world trade by volume. [63][33][67] Refined oil, or could be called product oil, plays a significant role in the shipping transportation of liquid. With China's rapid economic growth and urbanisation, its demand for refined oil was soaring in the last decades. [1]

Despite its significance, the sector is highly susceptible to disruptions, including economic downturns, natural disasters, geopolitical tensions, and regulatory changes. In recent years, China's refined oil shipping (CROS) industry has faced various challenges and disruptions, including fluctuating oil prices, geopolitical tensions, and environmental concerns[2]. Especially in the recent three years, the COVID-19 pandemic caused substantial economic shocks and exacerbated the vulnerability and uncertainty of the macroeconomic system [2][46]. These factors have highlighted the need for a resilient refined oil shipping market that can effectively respond to and recover from such challenges. In this context, understanding the influencing factors of the CROS market[3] and identifying ways to enhance it is of paramount importance.

Given the increasing complexity of the international and China's domestic trade landscape, there is a pressing need for a comprehensive and reliable index to measure the prosperity of the refined oil transportation market in China. A Shipping Prosperity Index (PI) could serve as a valuable tool for policymakers, investors, and

[1] Based on the analysis of Company A, and the refined oil shipping market of China ramped up around 2015.

[2] The environmental concerns are mainly referred to governmental measures related to GHG emissions.

[3] The CROS market mainly refers to the domestic shipping of refined oil by the east coast of China.

industry stakeholders to understand the industry's robustness better and identify areas for improvement. This dissertation aims to develop a comprehensive prosperity index in refined oil shipping in China, which is called China's Refined Oil Shipping (CROS) Market Prosperity Index (PI), capturing the key factors influencing the industry's prosperity and providing a means for comparative analysis across China's related industries and shipping companies.

1.2 Objectives

The primary objectives of this study are threefold:

- To establish the CROS market PI, which will enable stakeholders to monitor the health and growth of the refined oil transportation industry effectively.
- To analyse the implications of the CROS market PI for Company A[4], a joint venture company invested by China COSCO SHIPPING Corporation Limited (ranking 127th in the Fortune 500) and PetroChina Company Limited (ranking 4th in the Fortune 500) that holds a significant market share in China's coastal refined oil transportation industry.[5]
- To contribute to the sustainable development of the CROS industry by providing an evidence-based tool for decision-making and policy formulation.

To achieve these goals, the research will:

- Conduct a thorough literature review to identify the relevant factors contributing to the prosperity of the CROS industry, including the research of shipping-related indices, the research of resilience indices, and the CROS market-related factors.
- Develop a methodological framework for constructing the CROS market PI, including the selection of appropriate indicators, data sources, and weighting schemes.
- Collect and analyse data from various sources, such as the industry reports and the author company's (Company A) statistics, to calculate the index for a selected sample of CROS market related sectors.
- Conduct a comparative analysis of the CROS market PI results, highlighting the strengths and weaknesses of different entities and identifying opportunities for improvement.

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[4] The author of this paper works for company A. For commercial confidentiality reasons, some data in the dissertation may have been processed, but the data logic has not been adjusted.

[5] Company A holds more than a quarter of the market share.

- Validate the CROS market PI through case studies to ensure the reliability and practical applicability of the index.

1.3 Questions

The main objective of this research is to develop a comprehensive understanding of the factors that contribute to the CROS market and to develop a PI. The research will address the following questions:

- What are the key characteristics and drivers of the CROS market?
- What factors contribute to the prosperity of the CROS market, and how can they be quantified and assessed?
- How can the CROS market PI be developed for the CROS market, and how can it be validated and applied in practice.

1.4 Significance

As the world's largest consumer and importer of oil (U.S. Energy Information Administration,2021), the CROS market directly impacts not only its domestic economy but also global energy markets. This research holds significance for several reasons:

- Initiating and enhancing the research in this specific area: By developing a PI tailored to the CROS market, the study will provide stakeholders with a valuable tool for assessing and enhancing the market's resilience.
- Supporting the market decisions: The study has practical implications for industry stakeholders, providing a comprehensive assessment of the sector, which guides decision-making.
- Facilitating policy-making: The research can inform policy decisions and regulatory frameworks, as it will provide insights into the factors that contribute to prosperity of the CORS market. Policymakers can use these insights to develop strategies for mitigating risks, and fostering a more sustainable CROS market.
- Facilitating international trade and global energy markets: China's demand for refined oil products significantly impacts global energy markets, and disruptions in its shipping sector can have far-reaching consequences. A robust and resilient CROS sector ensures that global trade flows remain consistent.

In summary, the development of an PI with a focus on the CROS sector has significant implications for enhancing China's energy security, facilitating policy-making, promoting sustainable shipping practices, and informing investment decisions. This research will contribute to the understanding of the factors affecting the prosperity of the CROS market and provide valuable insights for improving the robustness of this critical industry.

CHAPTER 2
LITERATURE REVIEW

2.1 The Research on Prosperity Index

Since the late seventeenth century, scholars have employed the concept of "economic cycles" to characterize the alternating periods of growth and contraction in the commercial economy. Previously, the study focused primarily on the analysis of economic crises and their causes over time.

It wasn't until the end of the nineteenth century that researchers began utilising modelling methods to examine economic cycles. In 1884, John Poynting introduced the concept of "moving averages" to identify trends in long-term economic activity and discern specific patterns. He used the colours light red and large red to represent economic fluctuations in France between 1877 and 1881. During this era, the techniques employed to analyse economic cycles were predominantly simple moving averages and graphical interpolations, with quantitative measures remaining relatively rudimentary.[65]

In 1904, Roger Ward Babson, an American entrepreneur, economist, and business theorist, established Babson's Statistical Organization[6], which analysed stocks and business reports. Its analysis includes 12 indicators in the areas of business, investment, etc. Later known as the Babson Index of Business Activity & Babson Chart, which reflects the macroeconomic conditions of the United States. It is also the first index to monitor the economic situation. [31] The fig. 2.1 showed failure regions were increasing (squares) and business was declining (circles).

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[6] Called Babson-United, Inc. today.

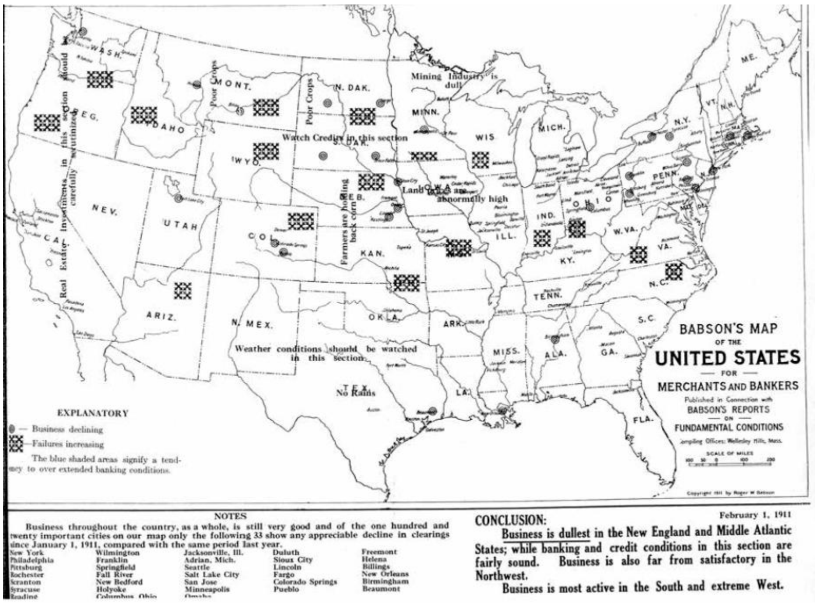


Fig. 2.1 Babson's Map of the United States for Merchants and Bankers
Source: Walter A. Friedman. A Selection of Early Forecasting & Business Charts. (2011).

Warren M. Persons' work "Indices of Business Conditions", which was published in 1919, used index numbers and moving averages in the analysing of the United States economy and predicting future economic conditions. He also worked on economic barometers and contributed significantly to the diffusion index (DI) methodology. [37] [21]

Systematic research on economic cycle indices is often attributed to the work of Wesley C. Mitchell and Arthur F. Burns at the National Bureau of Economic Research (NBER) in the United States. After conducting extensive, long-term research, Mitchell published his book "Business Cycles" in 1913, which later came to be regarded as a pioneering work in measuring economic cycle fluctuations. In 1927, he published another book, "Business Cycles - Problems and Adjustments," which provided a comprehensive summary of the methods and achievements related to measuring economic cycle fluctuations and establishing economic indices in the 20th century. [39]

In the mid-1930s, the United States faced another economic recession. Arthur F. Burns & Wesley C. Mitchell selected 71 reliable indicators from over 500 economic time series as recovery indices. They further narrowed this down to 21 leading indicators. These leading indicators successfully identified potential turning points in the economy. Mitchell and Burns published "Measuring Business Cycles" in 1946. This book discussed cycle separation, smoothing techniques, and trend adjustments, and introduced the idea that economic fluctuations are a gradual diffusion process across macroeconomic sectors – an idea that later became the theoretical foundation for diffusion index calculations.

In the post-war 1950s, the NBER, under the guidance of economist Geoffrey H. Moore, selected 21 of the most reliable cyclical indicators from nearly a thousand indicators and divided them into three categories: leading, coincident, and lagging. This new system of economic indices was adjusted and revised approximately every five years. [48] At the same time, the DI method was developed, which advanced the theory of economic index compilation significantly.

Starting in 1961, the NBER collaborated with the Bureau of Census, the Department of Commerce, and the President's Council of Economic Advisors. Under the leadership of G. H. Moore and Julius Shiskin, they began publishing a monthly report called "Business Cycle Development," which provided signals for macroeconomic trends. The collaboration between research institutions and government agencies greatly accelerated the development of economic monitoring research.[49]

In 1931, Macauley proposed the use of the moving average ratio method to seasonally adjust time series data and remove the impact of seasonal factors. [28] In 1954, Julius Shiskin first developed the seasonal adjustment program X1, and subsequent improvements were indicated by adding numerical sequences after the letter X. The seasonal adjustment program X11, developed by the US Bureau of Census, Department of Commerce in 1965, truly marked the widespread recognition and maturity of seasonal adjustment methods. It received high praise and quickly became the standard method adopted by statistical agencies worldwide, and it is still widely used today.

In terms of the theoretical methods for economic monitoring systems, the DI could only measure the direction of economic change, not the strength of economic fluctuations. In 1967, Moore and Shiskin developed a new economic index method, the Composite Index (CI), which was put into use in 1968.

The CI selects sensitive and reliable indicators from various major economic indicators representing different economic activities. It then combines the changes in these indicators to measure the magnitude of economic fluctuations. The CI measures not only the direction of economic fluctuations but also their amplitude, compensating for the shortcomings of the DI and improving macroeconomic business cycle monitoring theories. Most countries and organisations (such as the

OECD) use the CI to monitor and analyse economic fluctuations in different countries and international economic cycles. The CI and the DI have become the fundamental methods for constructing economic early warning systems for business cycle monitoring. [41]

In 1978, the Organization for Economic Cooperation and Development (OECD) adopted this business cycle analysis method to compile macroeconomic sentiment indices for its member states. In 1979, under the leadership of Moore, the NBER established the Centre for International Business Cycle Research (CIBCR) at Columbia University. They developed an International Economic Indicator system (IEI) based on the economies of the United States, France, the United Kingdom, Canada, Germany, Italy, and Japan, which was used to monitor the economic conditions of major Western countries.

In 1984, Japan's Asian Economic Research Institute conducted research on regional economic cycle fluctuations in various Asian countries and regions. Subsequently, countries participating in this research project, such as Singapore, Malaysia, Indonesia, the Philippines, South Korea, India, and Thailand, established their own monitoring and early warning systems, which greatly supported macroeconomic management. Since the 1990s, business cycle monitoring methods have gradually been applied and referenced in the analysis and research of various industries. [49]

In developing business cycle indices, scholars have tried to use factor analysis, principal component analysis, and other methods to analyse data containing numerous time series. Among these, the most influential research in the application of dynamic factor models (DFMs) is that of Stock and Watson. They use DFMs to capture this "common component" and subsequently construct a business cycle index. This new index is called the "Stock-Watson Business Cycle Index" or "SW Business Cycle Index." Its fundamental idea is that changes in economic conditions should not only focus on GDP fluctuations. Still, it should also view the business cycle as a broader cycle of economic activities, including labour markets, capital markets, and commodity sales markets.[55]

Business cycle monitoring technology has also been combined with traditional econometric models, classical equilibrium theory, disequilibrium theory, rational expectations theory, new supply-side theory, and system dynamics models, resulting in many new research findings. After nearly a century of development, the theoretical foundation of business cycle analysis methods has become increasingly refined and mature.

2.2 The Research on Prosperity Index in China

Research on economic cycles in China started relatively late. The economic slowdown that occurred after the rapid economic development in 1984 and 1985 played a driving role in the study of economic cycle fluctuations in China. Wu Jiapei and Liu Shucheng (1985) were the first to propose the problem of cyclical fluctuations in the socialist economic environment. Subsequently, Liu (1986) studied the cyclicality of fixed asset investment in China and its formation reasons. This series of studies showed that China's research on economic cycle fluctuations had broken through the previous taboo and began to develop in depth.[43]

In terms of monitoring macroeconomic performance, the Institute of Quantitative & Technological Economics (IQTE), CASS, the People's Bank of China, The State Information Centre (Administration Centre of China E-government Network), and Jilin University cooperated to develop a business cycle analysis and forecasting system, as well as related econometric models. This greatly promoted research on macroeconomic monitoring and forecasting.

In 1987, Dong Wenquan measured and analysed the fluctuations in China's economy for the first time. In 1988, Gao Tiemei and Dong established a macroeconomic early warning model of China’s economy. In the 1990s, Bi Dachuan, Liu , Zhu Jun, and Wang Changsheng studied the economic early warning systems to analyse China's economic cycle fluctuations. Chen Lei and other scholars used principal component analysis to study China's business cycle fluctuations. Chen, Gao, Dong, and other scholars used the SW business cycle index to analyse China's macroeconomic performance. Dong, Gao, and other scholars made a systematic exposition on the analysis and prediction methods of economic cycle fluctuations. In 2003, Gao and Wang Jinming used composite indices and other methods to analyse and monitor China's economic overheating. In 2006, Wang Jinming and Gao attempted to establish a business cycle index that reflects the common and asymmetric characteristics of China's economy using a dynamic Markov transition factor model. [11][22][23][24][43]

In January 1995, the China Real Estate Index System was launched. It is a system of indicators in the form of a price index to reflect the development trajectory and operational status of the real estate market in major cities across China. The index currently includes the "Zhongjing" DI and "Zhongjing" CI series.

In 1997, the National Bureau of Statistics established the National Real Estate Index, a comprehensive index reflecting the development and economic conditions of

China's real estate industry. It adopts the basic method and theory of the CI model and, based on the three basic starting points of land, capital, and market demand, selects the eight most typical and sensitive indicators as benchmarks for measurement.

In November 2002, the China Economic Prosperity Index began operation, compiled by the State Information Centre, hence also called the SIC Prosperity Index.

In recent years, macroeconomic monitoring and early warning systems have received increasing attention, and various provinces and cities in China have begun to develop and research economic sentiment early warning systems. There have been many domestic studies on some industry sectors in recent years. However, for the shipping industry, current research is limited and mostly focused on specific regions or countries. The Shanghai Shipping Index (SSI) focuses on the overall market sentiment of the global shipping industry, China Railway Express Prosperity Index studies the prosperity of the China-Europe Railway Line and its affecting factors, while research on business cycle monitoring for China Refined Oil Shipping (CROS) is still in its infancy. The relevant domestic and international research results have significant guiding and reference value for the compilation and research of the CROS business cycle index, both in theory and practice.

CHAPTER 3
METHODOLOGY

At present, prosperity cycle indices are widely used domestically and internationally to describe economic conditions. Prosperity cycle-related indices typically fall into two major categories: the Diffusion Index (DI) and the Composite Index (CI). The DI refers to the ratio of the number of expanding series to the total number of valid series within a certain period, which can reflect the direction of prosperity cycle fluctuations. On the other hand, the CI represents the overall average growth rate of all indicator series, which can reflect the magnitude of prosperity cycle fluctuations.

3.1 Principles and Improvement Methods for Compiling Diffusion Index

3.1.1 Calculation Method for the Traditional Diffusion Index

The DI refers to the ratio of the number of series in an expanding state to the total number of valid series within a certain period [66]. The advantage of the DI method is that it uses a set of indicators for comprehensive analysis, avoiding the drawbacks of relying solely on individual indicators for judgment and prediction. Its primary condition is to establish a comprehensive, timely, and accurate indicator system that reflects the development and changes of the subject being monitored for economic conditions. The core content is to divide the indicators in the system into three categories (leading indicators, coincident indicators, and lagging indicators) and calculate the diffusion index for each category. The DI series can vividly depict the dynamic process of successive diffusion in economic cycle fluctuations [74].

When calculating the DI, if the value of a particular indicator at the time 't' is greater than the previous month (or 'j' months ago), it is marked with a "+" sign; if it is smaller, it is marked with a "-" sign. If both values are equal, it is marked with 0.5 "+" signs. A "+" sign represents an expanding state. The total number of "+" signs in a large category of indicators divided by the total number of indicators, multiplied by 100, gives the diffusion index value for that category for the current month, i.e., the leading diffusion index, coincident diffusion index, and lagging diffusion index values [60].

The calculation formula for the traditional Diffusion Index (DI) can be expressed as follows:

$$DI_t = \frac{\sum I\,[x_t, x_{t-j}]}{N} \times 100\% = \frac{Increased\ number\ of\ T\ series}{Total\ number\ of\ T\ series} \times 100\%$$

e.g., if there are a total of "m" leading indicators, and at time "t," "k" of them are in the expansion state.

$$DI_t = \frac{\sum I\,[x_t, x_{t-j}]}{N} \times 100\% = \frac{k}{M} \times 100\%$$

Among them, "j" represents the base period, and the definition of the indicator function I[•] is as follows:

$$I[\bullet] = \begin{cases} 1 & x_t^i > x_{t-j}^i \\ 0.5 & x_t^i = x_{t-j}^i \\ 0 & x_t^i < x_{t-j}^i \end{cases}$$

x_t^i represents the sequence value of the "i"-th indicator time series at time "t". Therefore, for a specific "i" and "j", the corresponding range of values for "I" is between 0 and 1. In general, there are only three possible values for the indicator function: 0, 0.5, and 1. At this point, the indicator function is determined. However, when calculating the DI value, different weights can be assigned to each indicator based on their importance, reliability, and other factors. These weights are typically determined by expert scoring or dynamic weighting methods.

From the calculation method of the traditional DI, when $0.5 < DI \leq 1$, more than half of the indicators in this category are in an upward trend, indicating that the economy reflected by these indicators is generally expanding, i.e., in an upward phase of prosperity. Conversely, when $0 \leq DI < 0.5$, more than half of the indicators in this category are in a downward trend, indicating that the economy reflected by these indicators is generally contracting, i.e., in a downward phase of prosperity. When the DI value is 0.5, it has a special significance. It indicates that the prosperity of the economy is at a turning point. When the DI value decreases from greater than 0.5 to 0.5, the turning point is called a "trough," while when the DI value increases from less than 0.5 to 0.5, the turning point is called a "peak." Therefore, DI=0.5 is called the "prosperity turning point line," and it is also known as the "prosperity peak-trough line." [38]

Using the above calculation method, it is possible to calculate the leading DI, coincident DI, and lagging DI, each of which represents the "peak" and "trough" of economic prosperity. Previous research shown leading DI often precede the coincident DI, while the lagging DI also lag the coincident DI. The coincident DI generally synchronizes with the economic cycle.

3.1.2 Optimized Calculation Method for Diffusion Index

The traditional diffusion index algorithm only reflects the proportion of expansion sequences in the selected indicators and does not consider the impact of the degree of expansion on the DI value. Therefore, it cannot accurately reflect the position, potential, and peaks and valleys of the wave diffusion. In order to overcome the problems of wave distortion and instability caused by the traditional DI algorithm, this article refers to the improvement of the traditional DI algorithm proposed by Li Bin and Ding Lieyun (2003) and improves the indicator function in the algorithm. The calculation method of the optimized DI is as follows:

$$DI_t = \sum_{i=1}^{n} w_i U_{P_{ij}} / \sum_{i=1}^{n} w_i$$

The original non-continuous indicator function has been modified to a continuous wave intensity index function.

$$U_{p_j j} = (\frac{u_{ij}}{c_i})^{\lambda}$$

Where:

(1) u_{ij} is the volatility of the $(x^i_1, x^i_2, \ldots, x^i_n)$ - th time series of the i-th indicator, that is,

$$u_{ij} = (x^i_j - x^i_{j-1})/x^i_{j-1}$$

(2) c_i is the maximum absolute value of the volatility u_{ij} in each period.

(3) λ is an introduced "preference operator" whose selection depends on the growth mode of the growth rate of each indicator in the previous stage. When the indicator sequence belongs to a geometric growth pattern, λ can be chosen as 1. When the growth rate is faster in the current period and slower in the later period, an appropriate value between (0,1) can be chosen. When the growth rate is slower in the current period and faster in the later period, an appropriate value greater than 1 can be chosen.

3.2 Principles of Compilation of Composite Index

3.2.1 Calculation Method of Composite Index

Currently, there are three calculation methods for CI used internationally: (1) the CI method used by the US Department of Commerce and the NBER. The method used in this chapter is consistent with the CI calculation method of the NBER and the US Department of Commerce; (2) the calculation method of the Economic Planning Agency Survey Office of Japan, which is consistent with the idea of the US Department of Commerce, but with slight differences in method; (3) the OECD method. Based on the growth cycle, OECD compiled the prosperity index of each member country using a relatively simple method, determined the benchmark date for each member country, and analysed and predicted their economic conditions. [40]

The calculation method of the composite index in this article is as follows:

(1) Calculation of Symmetric Growth Rates and Standardization

Let $Y_{ij}(t)$ be the i-th indicator in the j-th group of indicators, where j=1,2,3 represents the leading, coincident, and lagging indicator groups respectively, and i=1,2,...,k_j is the index number within the group. k_j represents the total number of indicators in the j-th group, and n is the sample size. First, calculate the symmetric growth rate $C_{ij}(t)$ of $Y_{ij}(t)$:

$$C_{ij}(t) = Y_{ij}(t) - \frac{Y_{ij}(t-1)}{Y_{ij}(t) + Y_{ij}(t-1)} \times 200, t = 2,3,\ldots,n$$

Standardization will be applied to all C_{ij} (t) values of each indicator to make the average absolute value equal to 1. First, it is necessary to calculate the standardization factor A_{ij}.

$$A_{ij} = \sum_{i=2}^{n} \frac{|C_{ij}(t)|}{n-1}$$

After obtaining the standardization factor A_{ij}, it will be used to calculate the growth rate $S_{ij}(t)$ by substituting it into $C_{ij}(t)$:

$$S_{ij}(t) = \frac{C_{ij}(t)}{A_{ij}}, t = 2,3,\ldots,n$$

(2) Calculation of Composite Growth Rates for Each Indicator Group

First, calculate the composite growth rate $R_j(t)$ for each time point of the three indicator groups:

$$R_j(t) = \frac{\sum_{t=1}^{k_j} S_{ij}(t) \bullet w_{ij}}{\sum_{t=1}^{k_j} w_{ij}}, j = 1,2,3, t = 2,3,\ldots,n$$

Where w_{ij} is the weight of indicator i in group j. One method is to use equal weighting, that is, $w_{ij}=1$. Another approach is to use the scoring system invented by Moore and Shiskin, which balances the reflection of indicators on economic conditions, their statistical accuracy, and their correlation with economic cycles. However, the weight calculated by the scoring system has not received much attention because it does not provide more accurate or informative results than the equal weighting method.

Next, calculate the standardization factor F_j:

$$F_j = \frac{\left[\frac{\sum_{t=2}^{n} |R_j(t)|}{n-1}\right]}{\left[\sum_{t=2}^{n} \frac{|R_2(t)|}{n-1}\right]}, j = 1,2,3$$

And calculate the standardized composite growth rate V_j（t）:

$$V_j(t) = \frac{R_j(t)}{F_j}, t = 2,3,\ldots,n$$

The purpose of doing this is to enhance the comparability of the three indicators and to apply them as a coordinated and consistent system. [25]

(3) Calculation of CI

Finally, a CI is constructed with the base year set to 100. Let $CI_j(1)=100$, then:

$$CI_j(t) = CI_j(t-1) \times \frac{200 + V_j(t)}{200 - V_j(t)}, j = 1,2,3, t = 2,3,\ldots,n$$

Sometimes, in order to reduce irregular fluctuations, a moving average may be applied to the composite index $CI_j(t)$. [22]

3.2.2 Significance and Role of Composite Index

To compensate for the shortcomings of the DI which can only measure the direction, but not the magnitude, of economic fluctuations, the US NBER developed the CI method, which has been in use since 1968. The CI is used to characterize the state of the economy and the trend of its future development and to make predictions about economic recession and recovery. Like the DI, the CI selects the most sensitive indicators to economic conditions from a range of reliable indicators that represent various economic activities and then combines the symmetric growth rates of these indicators to measure the magnitude of economic fluctuations. The construction of the CI also involves the grouping of indicators into three categories: leading, coincident, and lagging, and each group has the same functions as the DI.

3.3 Cyclical Fluctuations and the Application of Prosperity Theory in China's Refined Oil Shipping Market

3.3.1 Overview of Economic Cycle Theory

The economy's cyclical fluctuation for expansion, recession, depression, and recovery is mainly driven by the interactions between stabilization and destabilization factors such as productivity, interest rate, financial friction, pricing, and investment. [8][19][36] The fluctuations of economic variables always exhibit some systematic and correlated movement. For a long time, people have summarized the characteristics of the movement rules of many economic indicators. However, the cyclical fluctuations of economic variables are not replicable, and there are significant differences between different categories of economic indicators. As Burns and Mitchell (1946) pointed out in their definition of economic cycles, an important fact about economic cycles is that no cycle will be a simple repetition of a previous cycle, and each cycle often exhibits significant differences in amplitude, scope, and duration.

However, according to the research of some famous economists, there are still some typical facts about the cyclical phenomena of regularity in a country's macroeconomy: Zarnowitz (1995) studied the expansion and contraction phases of the US in the first half of the 20th century and found that the duration of the expansion phase was getting longer and the duration of the contraction phase was getting shorter, and the amplitude of the fluctuations was decreasing. Moore and Zarnowitz (1986) studied long-term trends in prices and pointed out that prices rise during the expansion phase, especially during the prosperous phase when the utilization rate of capital and labour is high, and during the contraction phase, especially during prolonged depression periods, prices still rise but with a lower growth rate. Therefore, inflation is a continuous phenomenon. According to the research of Zarnowitz (1985) and Dore (1993), the cyclical fluctuations of various economic variables are compared with the general cycles of a country's economy. Except for agricultural and rare resource production, there is a high degree of similarity between the two in terms of the direction and time of fluctuations. Durable goods production, employment, and inventory have greater similarity and amplitude, while the cyclical fluctuations of non-durable goods are much lower, and the cyclical fluctuations of most service industries are weaker. King and Rebelo (1999) applied HP filtering to some major variables in the US and compared the results with output data that was also filtered using HP filtering. They found a quantitative match between these variables and output fluctuations. [26]

Typical facts about economic cycles have three main characteristics [42]: (1) Volatility. The fluctuations in non-durable goods sales, fiscal expenditures, capital, and other factors are less than that of output, while the fluctuations in durable goods sales and investment are greater than that of output. (2) Positive correlation. The fluctuations of many macroeconomic variables are in line with the cycles. (3) Continuity. Most macroeconomic variables have obvious continuity, and the first-order autocorrelation degree of seasonal statistical data after excluding trend factors can reach 0.9.

3.3.2 Cyclical Nature of the Shipping Market

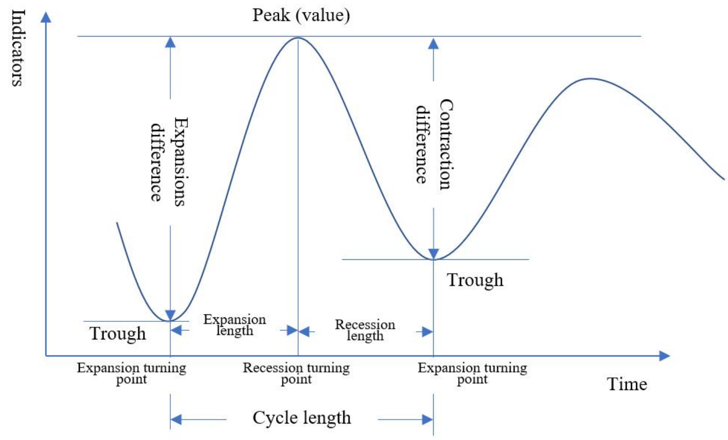
Shipping belongs to the service industry and is a demand derived from trade. It is highly open and has a degree of competition that surpasses other forms of transportation. It has economies of scale and requires coordination with other transportation methods, such as intermodal transportation. Shipping markets can be mainly divided into container shipping markets, dry bulk cargo shipping markets, and oil shipping markets according to their cargo types and transportation modes. As for their characteristics, container shipping is mainly operated by liner shipping companies, while dry bulk cargo and oil shipping correspond to the chartering market.

The shipping market has always been in a state of fluctuation. As an important component of the global economy, the shipping cycle is closely linked to the economic cycle. Shipping demand is closely linked to economic and trade development, but shipping supply has its own characteristics, so the shipping cycle is somewhat different from the economic cycle. Stopford pointed out in his book Maritime Economics that the shipping market cycle can be divided into three types: long cycles, short cycles, and seasonal cycles. Long cycles coincide with economic cycles and generally last for 60 years. Short cycles are generally 5 to 10 years, depending on the specific historical period, while seasonal cycles are even shorter, often less than a year. Among them, short cycles have the greatest impact on shipping companies and change quickly, making them difficult to grasp. According to market statistics from 1741 to 2007, the shipping market spent 74% of the time in a low period compared to a high period. In the shipping cycle, the upward phase is mostly stable, while the downward phase depends on the situation, making the length of the entire market cycle highly uncertain.

3.3.3 Statistical Analysis and Phasing of Economic Cycle Fluctuations

(1) Statistical analysis of economic cycle fluctuations

Statistical analysis of economic cycles involves conducting cyclical statistics on various economic phenomena manifested in national economic activities and then integrating them to reflect the statistical characteristics of the national economic



cycle.

Fig. 3.1 Statistical chart of the economic cycle

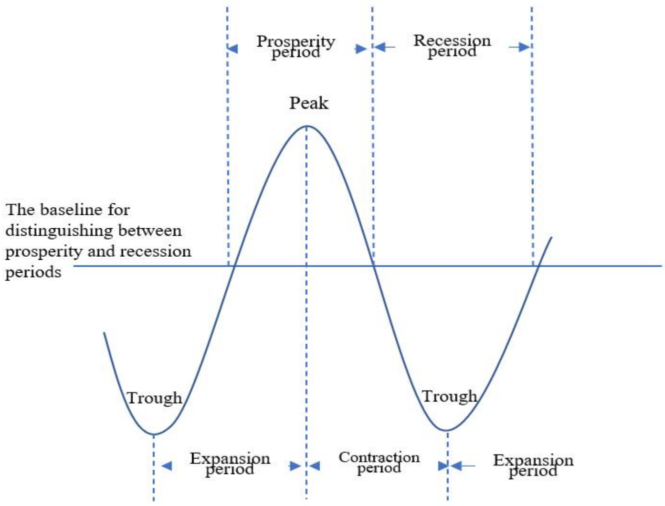
As shown in Fig. 3.1, there are several common concepts in the statistical analysis of prosperity cycles:

- Cycle time, which refers to the start and end time of a cycle;
- Cycle length, which is the time span from the start to the end of a cycle;
- Peak, which is the indicator value at the top of the cycle;
- Trough, which is the indicator value at the bottom of the cycle;
- Expansion length, which is the time span from the trough to the peak;
- Contraction length, which is the time span from the peak to the trough;
- Recession turning point, which is the time scale when the cycle reaches the peak;
- Expansion turning point, which is the time scale when the cycle reaches the trough;
- Expansion difference, which is the difference between the peak value of the current cycle and the trough value of the previous cycle;
- Contraction difference, which is the difference between the peak value and the trough value of the current cycle.

(2) Phases of Prosperity Cycles

There are two main ways to divide the phases of prosperity cycles (as shown in Fig. 3.2) [37]:

- Using a benchmark value as a measure, the period above the benchmark line is considered the prosperity period, and the period below it is considered the recession period.
- Using the direction of trend in the indicator as a dividing criterion, the interval from the lowest point to the peak is the expansion period, and the



interval from the peak to the lowest point is the contraction period.

Fig. 3.2 Stages of economic cycle fluctuations

3.3.4 Cyclical Volatility of China's Refined Oil Shipping Market

(1) The development of the CROS Market

The CROS market is a significant segment of China's shipping industry, and its fluctuations affect international refined oil shipping. Prior to 2015, the market had the characteristics of a planned economy, as state-owned enterprises such as Company A, which executes refined oil shipping on behalf of China National Petroleum Corporation (CNPC[7]), dominated the market with around 40-50% market share. Despite some fluctuations such as the impact of the 2008 financial crisis, the market was relatively stable and predictable.

However, the market's rapid development began around 2015 when private refineries emerged in Shandong province, breaking the market's previous balance dominated by state-owned enterprises such as CNPC, China Petrochemical Corporation (Sinopec)[8], and China National Offshore Oil Corporation (CNOOC)[9]. Private enterprises have since accelerated their integrated refining and chemical construction projects, resulting in the emergence of large-scale private integrated refining and chemical companies such as Hengli Petrochemical (2018) [10]and Zhejiang Petrochemical (2019)[11], which have become important players in China's oil and chemical industry. As a result, the market's characteristics have become more volatile, unpredictable, and cyclical.

Currently, the CROS market remains stable at a high volume of approximately 80 million tons, according to Company A's statistics. However, the Ministry of Transport of the People's Republic of China (MOT) strictly controls construction allowances, leading to limited increases in transportation capacity. The MOT reports that there are around 600 inter-provincial oil tankers operating along the coastal areas. Large enterprises are the primary participants in the upstream and downstream of the industry chain, and the industry's national energy security implications make it challenging to fully disclose information. Although private ship owners are part of the carriers, they have limited access to information.

[7] It is also called PetroChina, which refers to the part of CNPC that is listed in A and H shares.

[8] Ranked 5th in Fortune 500 in 2022.

[9] Ranked 65th in Fortune 500 in 2022.

[10] Its parent company Hengli Group, ranked 75th in Fortune 500 in 2020.

[11] Ranked 180th in Fortune 500 in 2022.

(2) The cyclical and fluctuating characteristics of the dry bulk shipping market.

However, there are periodic fluctuations in the market and imbalances in supply and demand. Issues such as resource providers holding back inventory and inadequate market supply, as well as low efficiency and weak profitability of shipping companies, are intertwined, and may even lead to fierce price competition. The CROS market exhibits typical characteristics of an economic cycle [71]: recovery phase, development phase, peak phase, and decline phase.

- recovery phase: The trend for freight rates or vessel rentals generally starts with an increase, followed by a certain degree of correction before continuing to rise. This is mainly due to the market having undergone a major adjustment, resulting in inertia-driven downward prices or rental trends, which may have fallen too low. The subsequent correction leads to the observed trend in freight rates or rental prices.
- Development phase: The trend for freight rates or vessel rentals is relatively simple, generally exhibiting a single upward trend. Although there may be adjustments during this period, the magnitude of the adjustments is usually small. The main reason for this is that China's consumer demand begins to improve, and the trade volume of refined oil starts to increase. However, due to the poor profitability of ships in the early stages, or the control of allowances by the MOT, the addition of new shipping capacity is insufficient, leading to an imbalance in supply and demand during this period, causing freight rates to rise.
- Peak phase: The trend for freight rates or vessel rentals is more complex, mainly due to the high-speed growth of refined oil demand, which leads to a sustained shortage of shipping capacity, causing freight rates to rise. Additionally, the CROS market is highly relevant to China's policy and refinery distribution plans, especially for state-owned enterprises. If refinery profitability increases, production rates will ramp up, and refinery storage may be in jeopardy, resulting in a breakdown of the balance between supply and demand for ships, causing refineries to compete for ships, leading to irrational growth in freight rates. This phase may also experience a decline in transportation efficiency due to adverse weather conditions, leading to further reductions in shipping capacity and pushing freight rates even higher.
- Decline phase: The market trend is generally downward. The main reason for this is that the sale price of refined oil in China is highly regulated by the government. For example, if the price of crude oil is too high, the government will control the sale price of refined oil in the market to control inflation and protect people's livelihoods. This causes the profitability of refining

businesses to be inverted, with state-owned refineries maintaining a certain scale of production to ensure people's livelihoods but not actively expanding production. Private refineries, on the other hand, generally reduce production rates to minimize losses. The demand for refined oil transportation in the market decreases sharply, leading to a significant drop in freight rates, and ships generally suffer losses. To reduce losses, some shipowners adopt measures such as reducing speed, selling ships, or scrapping ships. This results in a sluggish market for refined oil transportation.

3.3.5 Application of Prosperity Theory to China's Refined Oil Shipping Market

As the CROS market has become more market-oriented, it has experienced several expansions and recessions, influenced by many complex factors, including the COVID-19 pandemic. These factors have created turbulence in the supply and demand of the CROS market. For example, the development of private refineries in Shandong led to a shortage of ships for a long time, and the building process only slowed after the Ministry of Transport (MOT) implemented macro-control allowances in 2018, leading to a high price of freight in 2019.

The outbreak of COVID-19 resulted in the lowest freight volume in February 2020, but demand gradually increased as the pandemic in China was relatively controlled, reaching a relatively high volume in July 2020. As of 2021, the market has been relatively active. However, the COVID-19 pandemic was not fully under control, leading to a decline in the market until October 2022. The liberalisation of COVID-19 controls have since increased demand for construction and tourism, and the market has been relatively strong since then (as of May 2022).

Therefore, analysing the cyclical volatility of the CROS market, constructing a prosperity index that accurately reflects the industry's value level, grasping the overall market's prosperity and monitoring it, is of great significance for government departments, such as the MOT, to gain an in-depth understanding of China's coastal refined oil transportation market's volatility, industry investors and shipping companies to make decisions, implement effective resource allocation and operational management.

This article will specifically analyse the factors that affect the cyclical volatility of the CROS market, adopt theoretical methods for cycle judgment, select the optimized DI and the CI model mentioned above, and construct a prosperity index system for the CROS market, compiling the prosperity index.

CHAPTER 4
CONSTRUCTION OF CHINA'S REFINED OIL SHIPPING MARKET PROSPERITY INDEX

4.1 Selection of Prosperity Indicators

4.1.1 Principles for Selecting Prosperity Indicators

The fluctuations in the CROS market are not isolated but interconnected and mutually constrained. Prosperity indicators play a significant role in measuring the cyclical changes in the CORS and are crucial in constructing a PI system. Therefore, when constructing a PI system, not only should its completeness be considered from different perspectives, but also the non-redundancy of the indicators in reflecting market activity. According to the indicator selection methods of the National Bureau of Economic Research (NBER) in the United States and the experience of constructing other prosperity indices, the general principles for selecting prosperity indicators can be divided into several points [55]:

- Hierarchical principle: The PI is a complex system that involves various aspects and subsystems. Therefore, different indicators should be adopted at different levels.
- Stability principle: The analysis and forecasting of the PI mainly rely on the requirement that the selected indicators have relatively stable leading, consistent, and lagging tendencies in all cycles.
- Consistency principle: It is crucial to determine whether an indicator can be used as part of the PI system by assessing whether its fluctuations are consistent with the benchmark cycles.
- Representativeness principle: The PI system should be relatively complete, with each selected indicator reflecting various aspects of the CROS market. The selection of indicators should also emphasize their representativeness and typicality, and the number of indicators should be compressed as much as possible to simplify calculation and analysis.
- The smoothness principle: This principle requires that the fluctuations in indicators should be smooth, and irregular fluctuations should be relatively

small. Smooth fluctuations are more accurate and have more predictive significance than non-smooth fluctuations.

- Principles of data reliability and adequacy: The data sources for the PI must be accurate and reliable, and the statistical methods used should be consistent. The data should also be sufficient, with enough statistical sample intervals for pre-processing data requirements and to search for cyclic patterns in the historical data. From previous research experience, it is generally required to have sample data of more than 8 years or over 90 monthly intervals.

4.1.2 Selection and Explanation of Prosperity Indicators for China's Refined Oil Shipping Market

Based on the principles of selecting prosperity indicators mentioned above, the first step in establishing the prosperity indicator system for the CROS market is to determine the basic indicators for the system. The selection should consider the completeness, representativeness, and availability of the indicators. Through the research of Company A, other cargo owner enterprises, and shipping companies, combined with domestic and international experience and industry knowledge, and using the Delphi method to solicit expert opinions, a total of 10 indicators were selected from the supply, demand, price, and cost levels of the CROS market based on the structure of the analytic hierarchy process. The selection and explanation of the basic indicators are as follows:

4.1.2.1 The Demand of China's Refined Oil Shipping Market

The CROS market demand is influenced by factors like economic growth, industrial development, transportation needs, government policies, regional distribution, and global market dynamics. China's consistent economic growth and rapid industrialization drive energy demand, while China's expanding transportation network and government policies promoting cleaner energy affect refined oil consumption. Regional distribution of resources and global market dynamics, such as crude oil prices, also impact the demand for refined oil shipping. Understanding these factors can inform investment and strategic decisions in the industry.

Aside from the macro factors above, the most influential and specific factors which affect the market most on the demand side include:

(1) Purchasing Managers' Index (PMI): The PMI can provide valuable insights into the demand for the CROS market through its components, such as new orders, inventory levels, production, supplier deliveries, and

employment. A higher PMI indicates a growing manufacturing sector, which typically leads to increased demand for refined oil products and shipping services. Higher new orders and production levels result in a greater need for refined oil products, while higher inventory levels may indicate an oversupply, potentially reducing shipping demand. Slower supplier deliveries could signal supply chain bottlenecks, increasing the demand for shipping services to alleviate these constraints. Lastly, high employment level can lead to increased demand for refined oil. By following PMI trends, stakeholders

can better understand the potential demand for refined oil shipping services and make strategic decisions.

Fig.4.1 China's Purchasing Managers' Index
Source: The State Council of China - www.gov.cn, compiled by the author

(2) Production of refined oil: If the key industry players, such as state-owned enterprises CNPC and CNOOC, and private-owned refineries HENGLI Petrochemical, increase their production, the demand for refined oil rises. This growth accelerates the efficiency of shipping services to distributions, including manufacturing, construction, transportation, etc. Additionally, expanding operations and supplying both domestic and international markets contribute to the growing demand for refined oil shipping services. Thus, the productivity of refined oil and the activities of major industry players directly influence the demand side of the CROS market, shaping the market dynamics and requiring stakeholders to closely monitor and adjust their capacities accordingly.

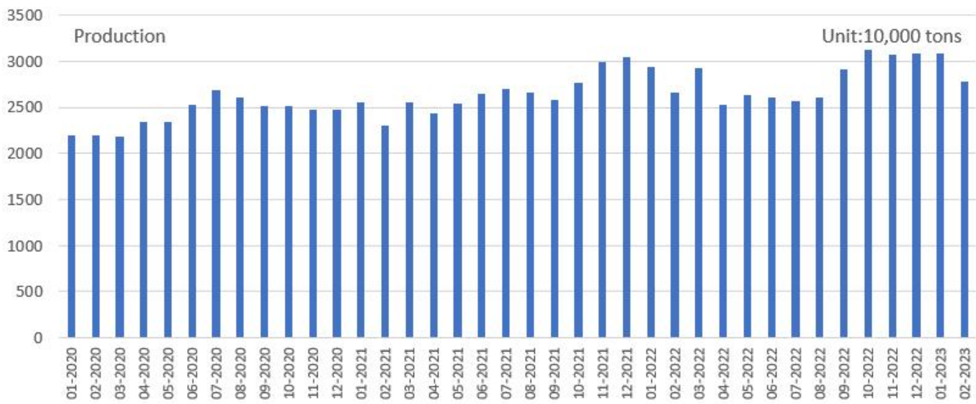


Fig. 4.2 Production of China's Refined Oil
Source: Sublime China Information – sci99.com, compiled by Company A

(3) Refined oil export quota: Chinese government controls the export quota of refined oil, which directly affects the availability of refined oil for China's domestic need. When the export quota increases, there is a higher demand for shipping services to transport the additional refined oil products to international markets and less demand for the CROS market. Conversely, a decrease in the export quota may reduce the demand for shipping services, as fewer refined oil products need to be transported internationally. As a result, the export quota of refined oil in China and the government's policies on international trade can significantly impact the demand side of the CROS market, shaping the market dynamics, and requiring stakeholders to closely monitor and adapt to the changing landscape.

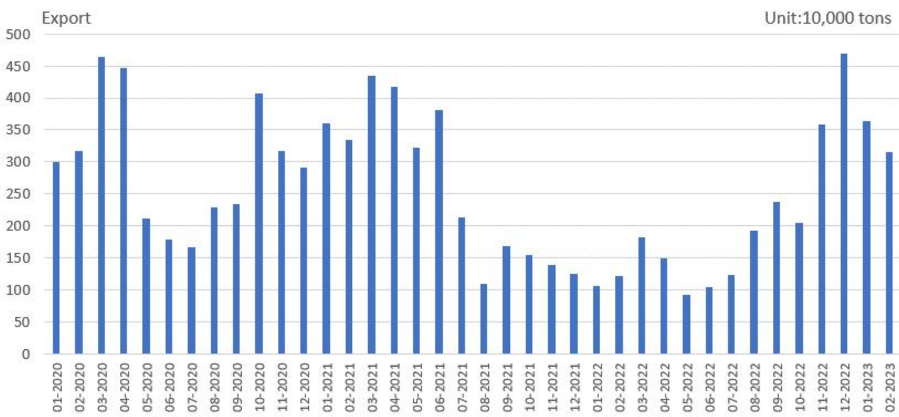
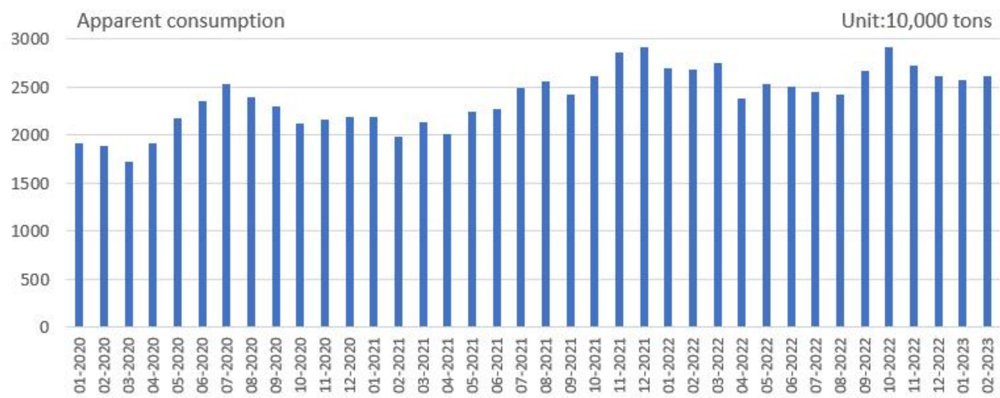


Fig. 4.3 Export of China's Refined Oil
Source: Sublime China Information – sci99.com, compiled by Company A

(4) Consumer demand for refined oil: Consumer demand for refined oil in China significantly impacts the country's refined oil shipping market. As the economy and population expand, the demand for refined oil products, such as gasoline, diesel, and jet fuel, increases across various sectors like transportation, power generation, and industrial processes. This heightened demand necessitates efficient transportation and distribution services. Furthermore, changes in consumer preferences and government policies, including shifts towards cleaner energy sources or electric vehicles, can influence the demand for traditional refined oil products and shipping services. Stakeholders in the shipping industry must closely monitor and adapt to evolving consumer demands and government policies to effectively address the market's changing needs. Coastal fuel storage limitations also affect shipping efficiency; for instance, if a CNPC storage facility in Ningbo port has a capacity of 50,000 tons, a single MR ship's unloading could nearly

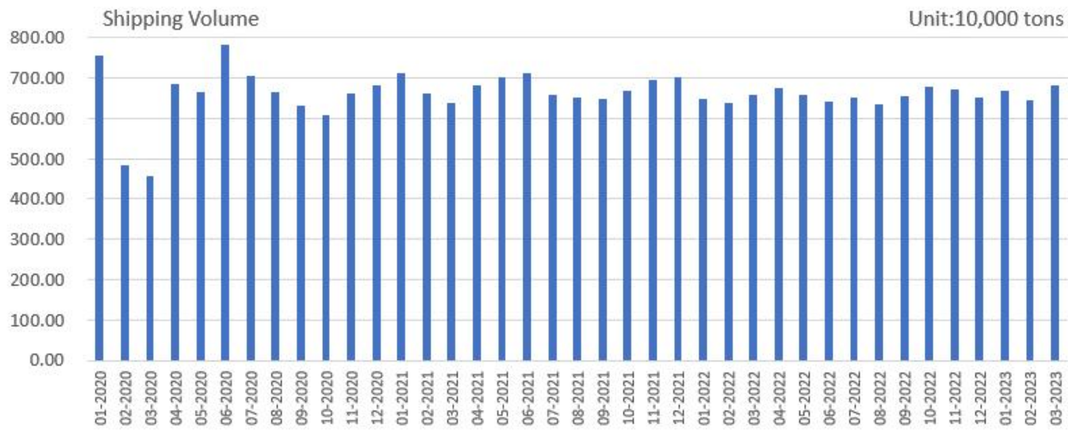


fill the storage, potentially causing confusion in redeployment plans.

Fig. 4.4 China's apparent consumption of refined oil
Source: National Bureau of Statistics, compiled by Company A

(5) Shipping volumes of refined oil: The shipping volumes of refined oil in China are directly correlated with the demand side of the CROS market. As the volume of refined oil products being transported increases, the need for efficient and reliable shipping services grows to accommodate the heightened demand. This growth is driven by factors such as economic expansion, industrial development, increased consumer demand, and fluctuations in export quotas. Conversely, a decline in shipping volumes could signify reduced demand for refined oil products, leading to a lower need for shipping services. Stakeholders in the refined oil shipping industry must closely

monitor the shipping volumes and market trends to adjust their capacities and



strategies accordingly.

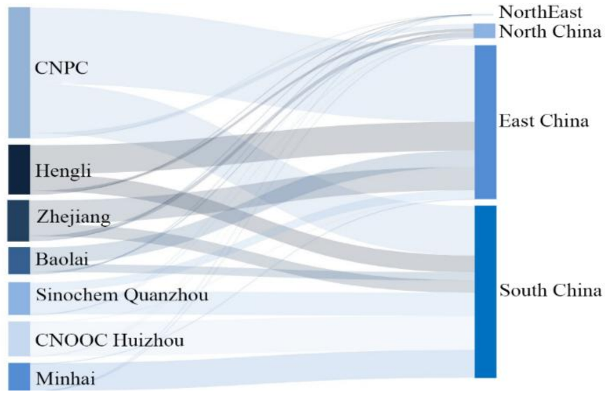


Fig. 4.5 The CROS volume
Source: The MOT, Compiled by Company A

Fig. 4.6 The CROS routes Sankey diagram (2020-2022)
[12]Source: Company A' analysis

4.1.2.2 Supply of Ships in China's Refined Oil Shipping Market

The supply of ships is strictly controlled by China's Ministry of Transport (MOT) through the newly built ships' quota, which significantly affects the CROS market.

[12] The CNPC here only includes the downstream resources from CNPC refineries in the Northeast of China. In 2023, with the commissioning of CNPC's Guangdong Petrochemical, the market environment has undergone significant changes. The current transportation market situation is inconsistent with the figure, and the market environment has not yet stabilized.

When the supply is abundant, shipping companies can meet the growing transportation demand, ensuring the timely distribution of refined oil. This can lead to increased competition among shipping companies, potentially driving down shipping freight rates and benefiting consumers through lower transportation costs. Conversely, a shortage of ships, as a result of strict quotas, can create bottlenecks in the distribution of refined oil products, leading to delays and higher shipping costs. As demand for refined oil continues to grow, a limited supply of ships could hinder the market's ability to accommodate the increasing transportation needs, resulting in higher prices and reduced access to refined oil products. Consequently, stakeholders in the shipping industry must closely monitor and adapt to the changing supply of ships, as regulated by the MOT, and invest in fleet expansion and modernization as needed to ensure the efficient and cost-effective transportation of refined oil products in China's dynamic market.

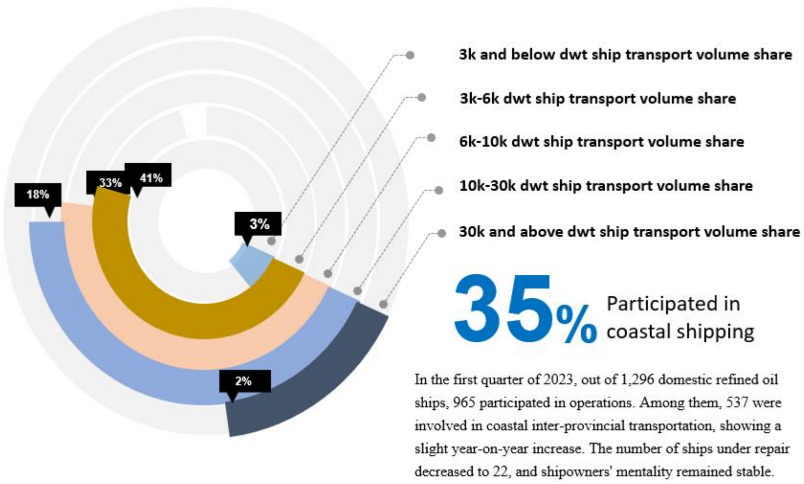


Fig.4.7 Distribution of tonnage for refined oil ships in China
Source: The MOT, compiled by company A

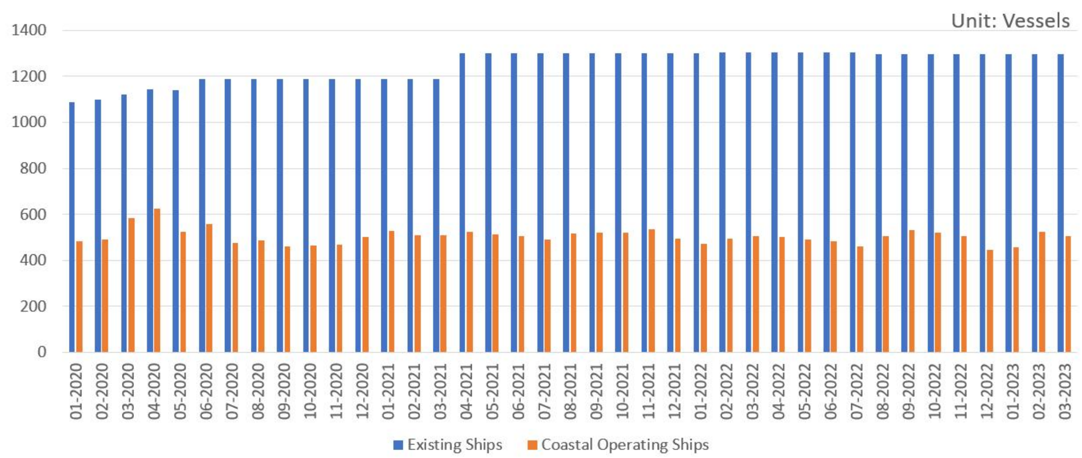
Table. 4.1 Characteristics of the CROS market in 2023 (ship-side)[13]

January 2023	There were 505 operating ships in the CROS coastal market, maintaining a relatively stable range.
February 2023	The market volume was weak, with some idle capacity and an evident oversupply.
March 2023	The CROS market demand surged, and with the return of international operation ships, the market supply and demand reached a tight balance.
1st quarter 2023	10,000-tonnage ships became mainstream in the market, especially after the strengthening of management in some ports.

Source: Company A's analysis

[13] The market analysis in the inland rivers of Chins is not included in the study.

In the CROS market, the supply of ships includes inland river ships and coastal ships. Both ship types are influenced by market factors such as oil prices; however, they differ in their adherence to regulations and ownership structures. Coastal ships, are built to higher standards, comply with the MOT regulations, and are operated by formal companies, ensuring quality, safety, and efficiency. In contrast, some of the inland river ships are owned by private individuals and may not be as strictly regulated at an early age. Monitoring both ship types provide a comprehensive



understanding of the market.

Fig. 4.8 Comparison of China's existing ships and coastal operating ships
Source: The MOT, compiled by Company A

4.1.2.3 China Coastal Tanker Freight Index

The China Coastal Tanker Freight Index (CCTFI) [14]is a shipping index that tracks the shipping rates of refined oil along China's coastal waters. The CCTFI is based on a weighted average of freight rates for the typical shipping routes and published weekly by the Shanghai Shipping Exchange. It serves as an important benchmark for the CROS market and is monitored by market participants for analysing, and is an important indicator of supply and demand for the CROS, as well as the overall health of China's economy.

[14] Company A is the chair member of the index.

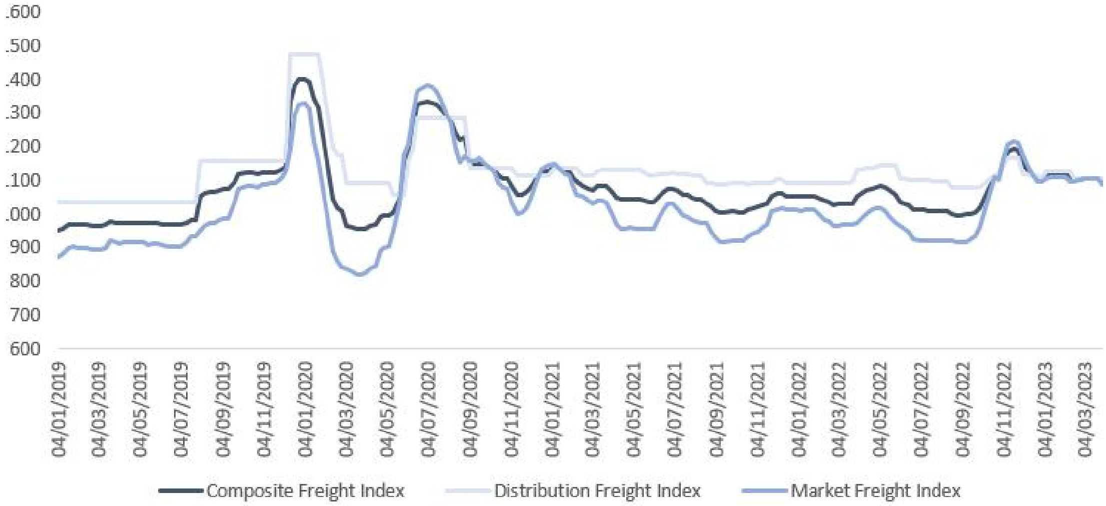


Fig. 4.9 The trend of the China Coastal Tanker Freight Index
Source: Shanghai Shipping Exchange, compiled by Company A

4.1.2.4 The Costs of China's Refined Oil Shipping Market

The bunker prices and remuneration of seafarers dominate the highest proportion of variable costs. Bunker prices can constitute up to half of the total variable costs, and is subject to fluctuations of global oil prices, regional supply and demand, and environmental regulations[15]. On the other hand, seafarers' remuneration can vary depending on their experience, qualifications, etc. Therefore, stakeholders in the shipping industry must closely monitor and manage these expenses to ensure efficient and cost-effective operations in the CROS market.

[15] Such as low-sulphur fuel requirements.

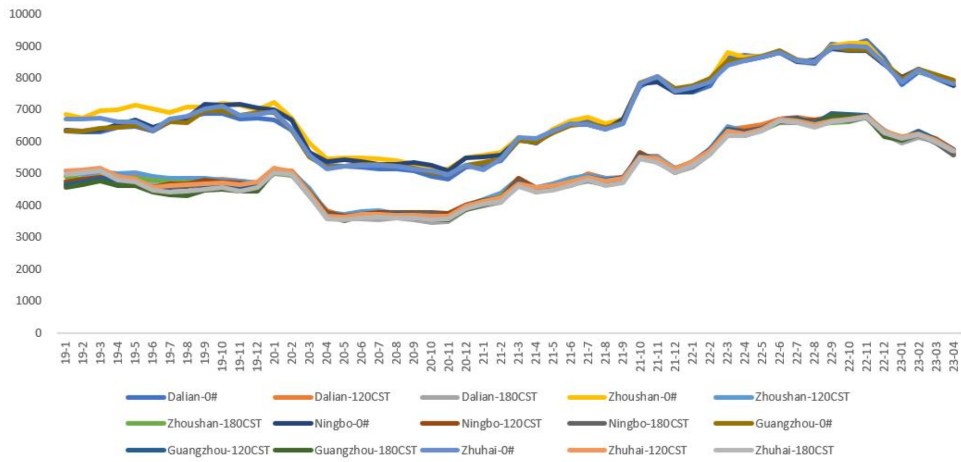


Fig. 4.10 Bunker price trend in China

Source: OilChem China, compiled by Company A

4.2 Weigh Setting of the Prosperity Indicators

4.2.1 Setting Indicator Weights for Diffusion Index and Optimized Diffusion Index Using the Delphi Method

After establishing the basic indicator series, it is necessary to set the indicator weights for the DI and the optimized DI. In the traditional DI algorithm, an equal weight method is adopted. However, in the optimized DI algorithm, the weight of the i - th group of volatility strength functions in the final DI needs to be set separately.

During the calculation of the prosperity index (PI), a total of 4 categories and 10 indicators were selected, with different weights assigned to each indicator in the trial calculation process. Determining the indicator weights has always been an important issue in the process of establishing various PI indicator systems. This paper adopts the Delphi method to qualitatively determine the indicator weights.

The Delphi method has the following characteristics: Firstly, it formulates corresponding evaluation levels and standards based on specific evaluation targets; secondly, scoring is intuitive, and each level standard is realized through scoring; furthermore, its calculation is relatively simple, and the selection scope is relatively broad; finally, the Delphi method takes into consideration both quantifiable and non-calculable evaluation items, making it more comprehensive.

Ultimately, using the Delphi method and incorporating expert opinions, adjustments were made to accommodate the actual situation. During the calculation process for the DI and the ODI, the adopted indicator weight settings are presented in Table 4.2

Table. 4.2 Weigh Setting of the CROS Index Indicators

Category	Indicators	Specific Indicators	Unit	Weight Setting	Total Category Weight
Supply	The CROS Existing Ships	Existing Ships	Vessels	0.10	0.20
	The CROS Operating Ships	Coastal Operating Ships	Vessels	0.10	
Demand	Macro-economic Situation	PMI	Points	0.05	0.45
	China's Refined Oil (CRO) Production Volume	Refined Oil Production	10,000 Tons	0.05	
	The CRO Export Quota/Plan	Export Volume	10,000 Tons	0.10	
	The CRO Consumption Demand	Apparent Consumption Volume	10,000 Tons	0.08	
	The CROS Volume	Monthly Shipping Volume	10,000 Tons	0.17	
Prices	CCTFI	CCTFI	Points	0.15	0.15
Costs	Bunker Costs	180 CST Price	Yuan/Ton	0.12	0.20
	Crew Cost	China Crew's Remuneration Index	Points	0.08	

4.2.2 Setting Indicator Weights for the Composite Index

When setting the weights for each indicator in the CI, one can use equal weights or consider factors such as the indicator's importance and its relationship with economic cycle timing, adopting a scoring system for calculation. However, the scoring method for setting weights does not necessarily have an advantage over the equal weight approach. The CI primarily focuses on reflecting the overall level of economic activity growth and the extent of prosperity in each stage. Artificially setting weights may not yield more useful information. Therefore, this article employs an equal weight approach to set the weights for each component in the CI.

4.3 Classification of China's Refined Oil Shipping Market Prosperity Indicators

4.3.1 Classification Principles for China's Refined Oil Shipping Market Prosperity Indicators

Indicators reflecting economic changes have differences in both content and timing. From the perspective of economic activity fluctuations, some indicators show signs of change before they occur, such as an upward trend before expansion or a downward trend before economic contraction. Other indicators exhibit similar characteristics only after economic operations have changed, rising after the economy has recovered for a while, or falling after it has declined for some time.

There are three types of relationships between indicator changes and overall economic changes in terms of timing, namely leading, coincident, and lagging indicators, based on the nature of the indicator changes. Economic fluctuation monitoring and analysis utilize these relationships to carry out an analysis of economic conditions, which is a distinctive feature that sets it apart from other economic statistical analyses.

- Leading indicators: Relative to the reference period and reference date, some indicators consistently or predominantly reach their peak or trough values before economic fluctuations occur, meaning they change ahead of economic fluctuations. These indicators have significant reference values for predicting the turning points of economic fluctuations. Selection criteria for leading indicators include: a clear and definite relationship from an economic perspective; a peak value that leads the benchmark cycle peak by at least three months, maintaining a leading position in at least two out of three consecutive cyclical fluctuations, and leading by more than three months.
- Coincident indicators: These indicators are used to depict the overall economic trajectory, determine the peak and trough positions of economic activity, and provide a reference trajectory. They often coincide with economic fluctuations relative to the benchmark date and play a crucial role in determining the start and end times of past economic fluctuations. The selection criteria for coincident indicators are a clear synchronous characteristic with the quasi-cycle from an economic perspective; a peak value close to the benchmark cycle peak, with a peak difference within two months.
- Lagging indicators: Relative to the benchmark cycle and reference date, some indicators tend to lag behind economic fluctuations in reaching their peak or trough values in each economic fluctuation cycle. The selection criteria for lagging indicators are a definite lagging relationship from an economic perspective; a peak value that lags behind the benchmark cycle peak by more than three months.

4.3.2 Classification of China's Refined Oil Shipping Market Prosperity Indicators

The indicators reflecting the CROS market's prosperity levels differ in both content and timing. In this paper, we will use the Kullback-Leibler (K-L) divergence method, along with the Delphi method, to classify the 10 indicators in Table 4.2 into leading, coincident, and lagging indicator groups.

4.3.2.1. Kullback-Leibler Divergence Method

In the mid-20th century, statisticians Kullback and Leibler introduced a measure of information, known as the Kullback-Leibler divergence, which is used to determine the closeness between two probability distributions. Over the past two decades, the K-L divergence has been applied to prosperity analysis. We will use this measure to select prosperity indicators.[37]

(1) The Basic Method of Kullback-Leibler Divergence

For random phenomena with chance properties, it is generally assumed that they follow a particular probability distribution of random variables. To evaluate the goodness of a model, given the known (or assumed) true probability distribution, a measure is needed, which is the Kullback-Leibler divergence. Let the random variable probability sequence be P={P1, P2,…, P_m}, where P_1 is the probability of time W_j occurring, and set $P_1 > 0$, $\sum_{i=1}^{m} P_i = 1$, Let the (evaluated) random variable probability distribution be q={q_1, q_2,…, q_3}, where q_i is the probability of the actual occurrence. Then, the expected $I(p,q) = \sum_{i=1}^{m} p_i In \frac{P_i}{q_i}$ is defined as the K-L divergence of distribution q with respect to distribution p.

It has the characteristics: $\sum_{i=1}^{m} p_i = \sum_{i=1}^{m} q_i = 1$. Set p, q satisfies the condition of $p_i > 0$, $q_i > 0$ (I = 1,2, …, m)

The Kullback-Leibler divergence has the following properties: $\sum_{i=1}^{m} p_i = \sum_{i=1}^{m} q_i = 1$. Let p and q be probability groups that satisfy $P_i > 0$ and $Q_i > 0$ (I = 1, 2, …, m), the defined I (p, q) satisfies: (1) I(p, q) ≥ 0; (2) $I(p,q) \Leftrightarrow p_i = q_i (i = 1,2,\ldots,m)$.

The negative of the K-L divergence is called negative entropy. When using the K-L divergence I(p, q) to measure the closeness, the smaller the value, the closer the distribution q is to the distribution p. Similar results apply to continuous distributions. Let g(x) be the density function of the random variable Y, and f(x) be the density function of the random variable X. Then, the K-L information of x with respect to y is defined as:

$$I(g,f) = \int_{\infty}^{\infty} In\,[\frac{g(x)}{f(x)}] \times g(x)df$$

(2) Calculation Principle of Kullback-Leibler Divergence Method

Let the benchmark indicator be y = (y_1, y_2, …, y_n). Since they all satisfy p1 > 0 and $\sum_{i=1}^{m} Pi = 1$, the sequence P can be considered as the probability distribution of a random variable. Therefore, by processing the benchmark indicators so that the sum of the indicators is equal to 1, we can obtain:

$$P_l = y_l/(\sum_{l=1}^{n} y_l), \text{ assuming } y_l > 0$$

After standardizing the selected indicator X = {X_1, X_2, …, X_n}, the sequence becomes q, then:

$$Q_l = x_l/(\sum_{j=1}^{n} x_l), \text{ assuming } x_l > 0$$

Thus, the final calculation formula can be derived:

$$K_l = \sum_{l=1}^{n} p_1 \times In\,(\frac{p_l}{q_{l+1}})\,; l = 0, \pm 1, \pm 2, \ldots, \pm l$$

Where l is the lead or lag period. The smaller the K-L divergence, the closer it is to 0, indicating that the indicator X is closer to the benchmark indicator Y.

4.4 Data Pre-processing for China’s Refined Oil Shipping Market Prosperity Index

To eliminate the impact of seasonal factors, random factors, and other influences, it is necessary to pre-process the data of each indicator group in the system before establishing the PI for the CROS market. Common data pre-processing processes include seasonal adjustment, trend alignment, and dimensionless processing.

4.4.1 Seasonal Adjustment

In prosperity analysis, monthly or quarterly time series of some statistical indicators may contain seasonal fluctuations or random factors caused by occasional events.

These factors can obscure changes in the objective development of the economy to some extent, making it difficult to study economic cycle fluctuations and prosperity changes. Seasonal adjustment refers to the elimination of seasonal or random factors from the time series of one or more statistical indicators, allowing the adjusted time series to reflect the economic situation more accurately.

Compared to raw data, the data after eliminating the influence of seasonal and random factors have the following five advantages:

- It can more accurately reflect the basic trend of the data itself. By scientifically measuring, separating, offsetting, and adjusting seasonal and random factors from the actual time series data, the time series can more accurately reflect the overall development trend of the indicators.
- The data is more comparable. Since the seasonal factors are eliminated after the adjustment, the data for different months or quarters can be directly compared.
- It can timely reflect short-term economic changes, especially turning points in economic fluctuations. This is valuable for analysing and studying economic cycle fluctuations and is also the most significant advantage of seasonal adjustment.
- Seasonally adjusted data can be converted to an annualized rate.
- Seasonally adjusted data can be used for short-term forecasting.

4.4.1.1. Time Series Decomposition Models

A monthly or quarterly economic time series is usually influenced by various factors. Generally, we can decompose these factors into four categories: long-term trend factors T (Trend), cyclical factors C (Cycle), seasonal variation factors S (Seasonal), and irregular factors I (Irregular) [70]. Long-term trend factor T represents the long-term trend characteristics of the time series; cyclical factor C is a kind of non-fixed periodic change, which may be a prosperity change or other cyclical change, used to characterize the fluctuations of an economy or industry; seasonal variation factor S is the cyclical change that recurs annually, generally referring to changes caused by factors such as rainfall, temperature, months within the year, policies, or holidays with a 12-month cycle; irregular factor I is caused by unpredictable random factors.

Based on these four components of the time series, three-time series decomposition models can be constructed: additive, multiplicative, and mixed models [29]. Assuming the time series is Y, these two basic models can be represented by the following formulas:

- Additive model: Y = T + C + S + I
- Multiplicative model: Y = T × C × S × I
- Mixed model: Y = T × C + S × I

In the additive model, T, C, S, and I are all expressed in absolute terms, and their measurement units are the same as the analysed object. However, due to the weak comparability between different economic variables, this model has considerable limitations. In the multiplicative model, except for T, which is an absolute quantity, the other variables are relative quantities (i.e., percentages), which can avoid the impact caused by measurement units. This model is more suitable for cases where T, C, and S are related. The mixed model combines the advantages of both the additive and multiplicative models, but its decomposition process is too cumbersome, and the analyzability and interpretability of the decomposition results are relatively poor. Therefore, in practical research work, the multiplicative model is more widely used than the additive model.

4.4.1.2. X-11 Seasonal Adjustment Method

In 1954, Julius Shiskin first developed the seasonal adjustment program X-1, and each subsequent improvement was indicated by adding a sequential number after X. The X-11 seasonal adjustment method was developed by the Bureau of Census, Department of Commerce in the United States in 1965. After its development, it received high praise and quickly became the standard method adopted by statistical agencies worldwide. This method has gone through several evolutions and has become a classic seasonal adjustment method widely used.

The statistical method used in the X-11 seasonal adjustment programme is to calculate the trend-cycle factors TC and seasonal factors S by applying symmetric moving averages, followed by processing. Its feature is that it can adapt to the characteristics of various economic indicators and choose calculation methods according to different seasonal adjustment purposes. Furthermore, it can automatically select calculation methods based on data characteristics without making choices, according to pre-coded statistical benchmarks. During the calculation process, decomposition is performed through several iterations, and each iteration further refines the estimation of the constituent factors.

The X-11 seasonal adjustment method includes additive and multiplicative models. The additive model decomposes the time series into the sum of trend-cycle factors TC, seasonal variation factors S, and irregular factors I, i.e., Y = TC + S + I. The multiplicative model decomposes the time series into the product of trend-cycle factors TC, seasonal variation factors S, and irregular factors I, i.e., Y = TC × S × I. The multiplicative model is only applicable when all series values are positive, and the number of seasonally adjusted observations is limited, requiring at least four full years of monthly or quarterly data but no more than 20 years of monthly data or 30 years of quarterly data [22].

In this study, using econometric statistical analysis software such as Stata 17.0, Eviews 10.0, and Excel, the X-11 seasonal adjustment method is employed, selecting the multiplicative model (Multiplicative) for data processing.

4.4.2 Synchronization Treatment

In multi-indicator comprehensive evaluation, some indicators are considered better when the value is larger, called positive indicators (also known as benefit-type indicators); some are considered better when the value is smaller, called negative indicators (also known as cost-type indicators or small-desirable indicators); and some are considered better when the value is closer to a certain value, called moderate indicators. During the comprehensive evaluation, it is necessary to synchronize the indicators first, usually by converting negative and moderate indicators into positive indicators, which is also called the positive transformation of indicators [68].

Common synchronization treatments include the following methods, where the actual value of an indicator is assumed to be x_i, and the processed value is y_i, for i=1,2,...,n.

- Minimum value method

$$y_i = x_{min}/x_i$$

- Maximum value method

$$y_i = 1 - x_i/x_{min}$$

- Reciprocal method

The minimum value method and the maximum value method are suitable for situations with appropriate threshold values. However, in practical applications, since suitable threshold values are difficult to obtain, many scholars often use the method of taking the reciprocal of the indicators:

$$y_i = 1/x_i$$

In the CROS market PI system, some indicators e.g., bunker prices, are negative indicators, but these indicators lack appropriate threshold values. Therefore, the reciprocal method was used to synchronize the data of these indicators.

4.4.3 Dimensionless Treatment

For dimensionless treatment, there are three different methods found in the current literature: range normalization, standardization, and mean normalization [68]. Suppose there are n units and m indicators in the PI system, x_{ij} represents the j - th original indicator value of the i - th unit, and y_{ij} represents the dimensionless j - th indicator value of the i - th unit, where i=1,2,...,n; j=1,2,...,m.

- Range Normalization Method

$$y_{ij} = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} \times \min x_{ij}}$$

The denominator in this method is only related to the maximum and minimum values of the indicator. When the difference between the maximum and minimum values of x_j is very large, the value of y_j will be small, which can be considered as reducing the weight of the j - th indicator. Conversely, when the difference between the maximum and minimum values of x_j is very small, the value of y_j will be large, which can be considered as increasing the weight of the j - th indicator. Therefore, it is not feasible to use this method for dimensionless treatment in a multi-indicator evaluation system.

- Standardization Method

This is currently the most commonly used dimensionless treatment method, and its calculation formula is:

$$y_{ij} = \frac{x_{ij} - \bar{x}_j}{\sigma_j}$$

Where $\bar{x}_j = \frac{\sum_{i=1}^{m} x_j}{m}, \sigma_j = \sqrt{\frac{\sum (x_j - \bar{x}_j)^2}{m-1}}$, they represent the mean and standard deviation of the indicator x_j, respectively. After standardization, the mean value of the indicator's y_j values is equal to 0 and the variance is equal to 1, eliminating the effects of dimensions and orders of magnitude.

- Mean Normalization Method

$$y_{ij} = \frac{x_{ij}}{\bar{x}_j}$$

The mean of each indicator after mean normalization treatment is equal to 1, and its variance is:

$$var\ (y_i) = E[(y_j - 1)^2 = \frac{E(x_j - \bar{x}_j}{\bar{x}^2} = \frac{var\ (x_j)}{\bar{x}^2} = (\frac{\sigma_j}{\bar{x}_j})^2$$

After seasonal adjustment and synchronization treatment, this study selects the standardization method and uses SPSS software for dimensionless treatment to eliminate the significant deviations in distance or similarity coefficient calculations caused by different dimensions or orders of magnitude between variables.

4.4.4 Data Treatment Results

Based on the treatment methods mentioned above, using Eviews for X-11 seasonal adjustment, and utilizing Stata 17.0 to calculate K-L information content, with shipping volume as the base indicator. The results are as follows:

Table. 4.3 K-L Information Content Calculation Results

Indicators	Optimal Periods	Information Content
The CROS Existing Ships	Lagged by 1 period	0.0005
The CROS Operating Ships	Leading by 13 periods	-0.0009
The CRO Consumption Volume	Lagged by 37 periods	-0.0006
The CRO Production Volume	Lagged by 1 period	-0.0008
The CRO Export Volume	Leading by 14 periods	-0.0111
PMI	Lagged by 8 periods	-0.0006
CCTFI	Leading by 32 periods	-0.0003
Bunker Prices	Lagged by 5 periods	-0.0022
Crew Salaries	Lagged by 37 periods	-0.0006

CHAPTER 5
COMPILATION OF CHINA'S REFINED OIL SHIPPING MARKET PROSPERITY INDEX

5.1 Compilation of the Diffusion Prosperity Index for China's Refined Oil Shipping Market

5.1.1 Trial Calculation of Traditional Diffusion Index

According to the traditional DI algorithm, the DI for the CROS market is compiled. The DI gives the percentage of expanding series in a given period to the total number of valid series within the group, reflecting economic cycle fluctuations to some extent.

After pre-processing the selected base indicators, including seasonal adjustment, trend alignment, and dimensionless processing, and combining the weights determined by the expert scoring method (Delphi method), calculations are performed separately for each group (leading, coincident, and diffusion group). As three months as standard, identified the type of indicators in Table 5.1.

Table 5.1 Type of the CROS PI Indicators

Type of Indicators	Indicators
Leading Indicators	The CROS Operating Ships, The CRO Export Volume, CCTFI
Coincident Indicators	The CROS Existing Ships, The CRO Production Volume, The CROS Volume

Lagging Indicators	The CRO Consumption Volume, Purchasing Managers' Index (PMI), Bunker Prices, Crew Salaries

The traditional DI for the CROS market from January 2020 to February 2023 is obtained, after performing inverse trend alignment for the 3 reverse indicators (The CRO Export Volume, Bunker Prices, and Crew Salaries), and performing standardization for all indicators, the calculation results are shown in Table 5.2.

Table 5.2 Calculation Results of the Traditional DI for the CROS Market Prosperity

Date	DI Leading Indicators	DI Coincident Indicators	DI Lagging Indicators	DI Composite Indicators
2020m1				
2020m2	0	66.67	50	40
2020m3	66.67	33.33	50	50
2020m4	66.67	100	75	80
2020m5	66.67	0	50	40
2020m6	100	100	75	90
2020m7	66.67	66.67	50	60
2020m8	0	66.67	0	20
2020m9	0	33.33	25	20
2020m10	33.33	33.33	50	40
2020m11	66.67	66.67	50	60
2020m12	100	66.67	75	80
2021m1	33.33	100	75	70
2021m2	33.33	33.33	50	40
2021m3	66.67	66.67	50	60
2021m4	33.33	66.67	25	40
2021m5	66.67	66.67	25	50
2021m6	0	66.67	0	20
2021m7	100	33.33	50	60
2021m8	33.33	100	25	50
2021m9	66.67	66.67	0	40
2021m10	33.33	100	50	60
2021m11	100	66.67	75	80
2021m12	66.67	100	50	70
2022m1	66.67	33.33	0	30
2022m2	33.33	66.67	50	50
2022m3	33.33	66.67	25	40

2022m4	66.67	0	0	20
2022m5	66.67	33.33	25	40
2022m6	0	0	50	20
2022m7	33.33	66.67	0	30
2022m8	66.67	66.67	50	60
2022m9	66.67	100	75	80
2022m10	66.67	100	50	70
2022m11	33.33	33.33	50	40
2022m12	0	66.67	50	40
2023m1	66.67	100	100	90
2023m2	100	66.67	100	90

According to the calculation results of the traditional DI, the leading, coincident, lagging, and composite indices of the CROS market prosperity DI are shown in Fig. 5.1.

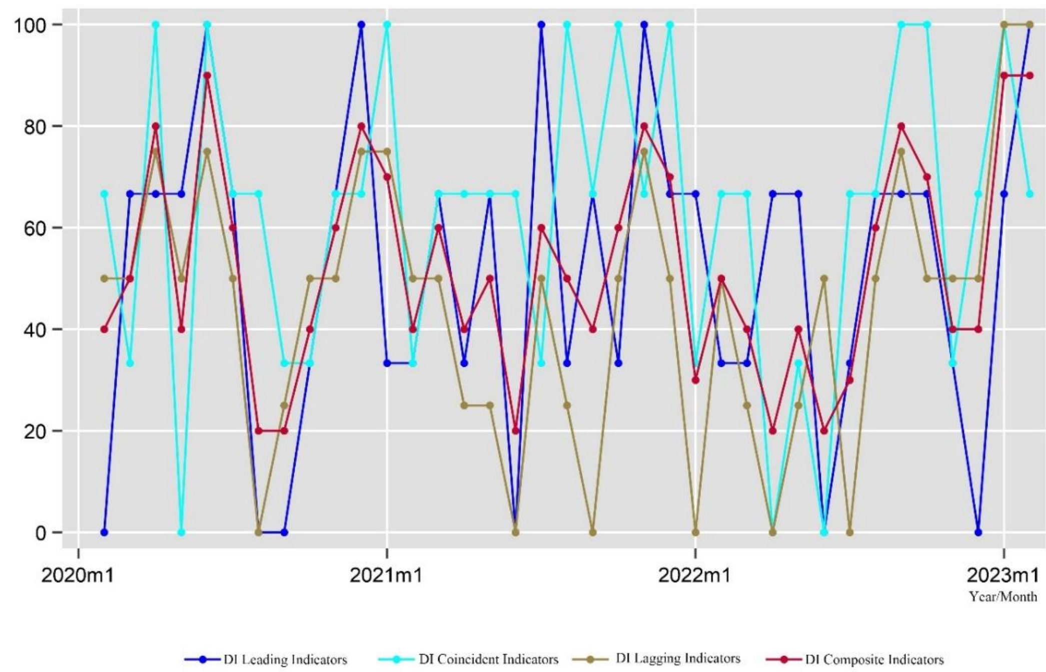


Fig. 5.1 Leading, Coincident, Lagging, and Composite DI Based on the Traditional DI Method

As can be seen, although the DI method can utilize multiple indicators to calculate results according to rules, it often leads to the amplification of waveform, fluctuation positions, peaks, and troughs due to not considering the impact of the degree of expansion on the overall results. This results in overly apparent fluctuations in the indicators, creating some false alarms and instability defects.

5.1.2 Optimized Diffusion Index Calculation

To address the false alarms and instability defects caused by the traditional DI calculation method, the determining principle of the indicative function in the traditional diffusion index is optimized as described in Chapter 3, optimizing it to the fluctuation indicative function. At the same time, after pre-processing the selected basic indicators and completing the seasonal adjustment and synchronization, the optimized DI algorithm is applied. The weights are consistent with the traditional diffusion index algorithm. Each group (leading, coincident, and diffusion group) is recalculated separately to compile the optimized diffusion index for the global shipping dry bulk market prosperity from January 2020 to February 2023, as shown in Table 5.3.

Table 5.3 Calculation Results of the Optimized DI for the CROS Market Prosperity

Date	Optimized DI Leading Indicators	Optimized DI Coincident Indicators	Optimized DI Lagging Indicators	Optimized DI Composite Indicators
2020m1				
2020m2	-12.11	-7.84	18.32	-3.51
2020m3	-10.14	-1.69	23.68	3.26
2020m4	2.3	-2.92	1.04	0.48
2020m5	-3.16	-43.48	-0.15	-15.11
2020m6	0.95	-27.82	-0.43	-8.9
2020m7	-2.79	-2.25	-0.24	-2
2020m8	-14.26	-2.65	37.64	1.94
2020m9	6.18	-4.46	0.29	0.43
2020m10	0.27	15.27	0.92	4.99
2020m11	-0.74	-3.06	0.42	-2.28
2020m12	4.12	-4.79	-1.78	-0.16
2021m1	-28.35	5.34	0.05	-7.85
2021m2	-3.29	-1.45	1.43	-2.34
2021m3	17.7	6.32	-1.64	7.54
2021m4	-4.16	-33.51	-0.53	-13.24
2021m5	-11.86	-14.57	-0.62	-10.33
2021m6	-3.68	-3.19	-1.52	-6.28
2021m7	-15.52	0.69	-3.19	1.82
2021m8	-2.98	-3.98	-40.23	-12.43
2021m9	0.22	1.63	0.5	2.17
2021m10	1.37	3.7	33.09	10.31
2021m11	2.27	2.28	-1.04	1.57
2021m12	-4.6	1.77	1.82	-0.21

2022m1	-1.52	-2.9	-0.56	-1.03
2022m2	12.88	0.48	-2.69	4.32
2022m3	0.35	-15.31	-0.15	-4.63
2022m4	0.39	-7.02	1.44	-1.45
2022m5	-1.69	0.66	-0.19	-0.36
2022m6	-40.98	-1.57	-0.18	-14.95
2022m7	-1.76	-14.37	0.07	-5.09
2022m8	-4.7	-1.6	-0.13	-2
2022m9	21.49	-1.56	-3.28	6.27
2022m10	-2.79	3.89	2.41	0.7
2022m11	-31.44	0.3	0.43	-10.98
2022m12	26.73	-51.3	-0.42	-7.36
2023m1	-2.77	0.92	-0.63	-1.06
2023m2	7.61	-1.16	-12.34	-0.6

According to the calculation results of the optimized DI, the leading, coincident, lagging, and composite indices of China's refined oil transportation market prosperity are shown in Figure 5.2.

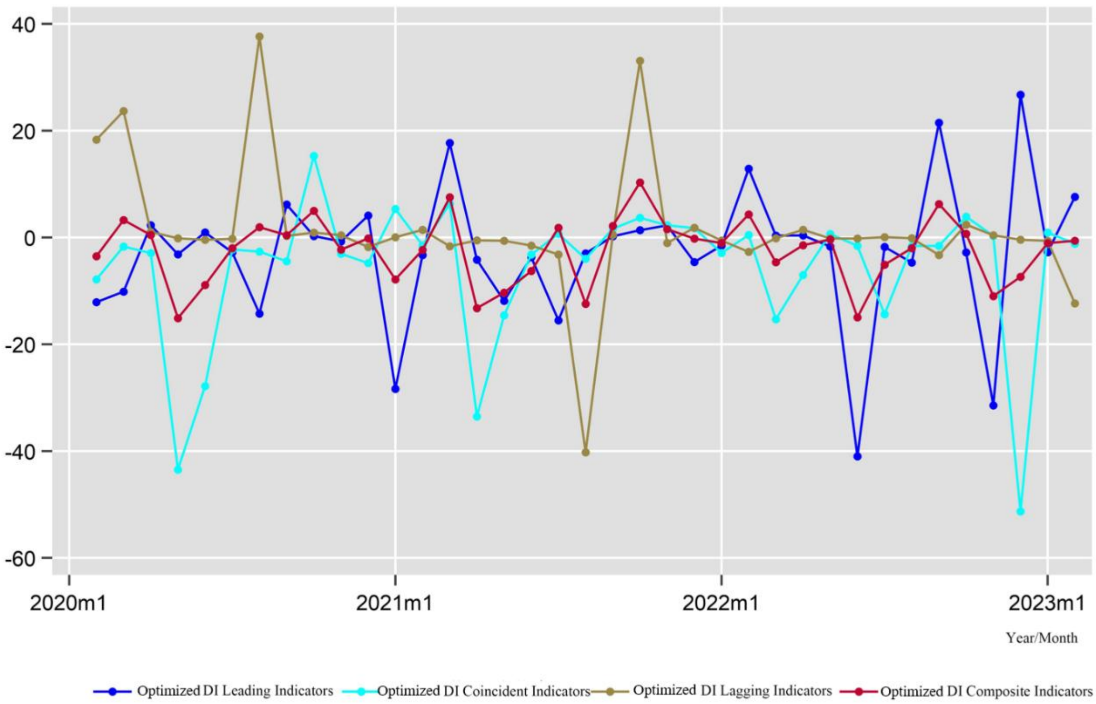


Fig. 5.2 Leading, Coincident, Lagging, and Composite DI Based on the Optimized DI Method

The optimized DI is derived from the traditional DI by refining the algorithm. In this paper, the two sets of indices are compared within the same range. One point to note is that the value range of the traditional DI is (0,100) with the dividing line for prosperity and decline at 50, while the optimized DI has a value range of (-100,100) with the dividing line at 0. See Figure 5.3.

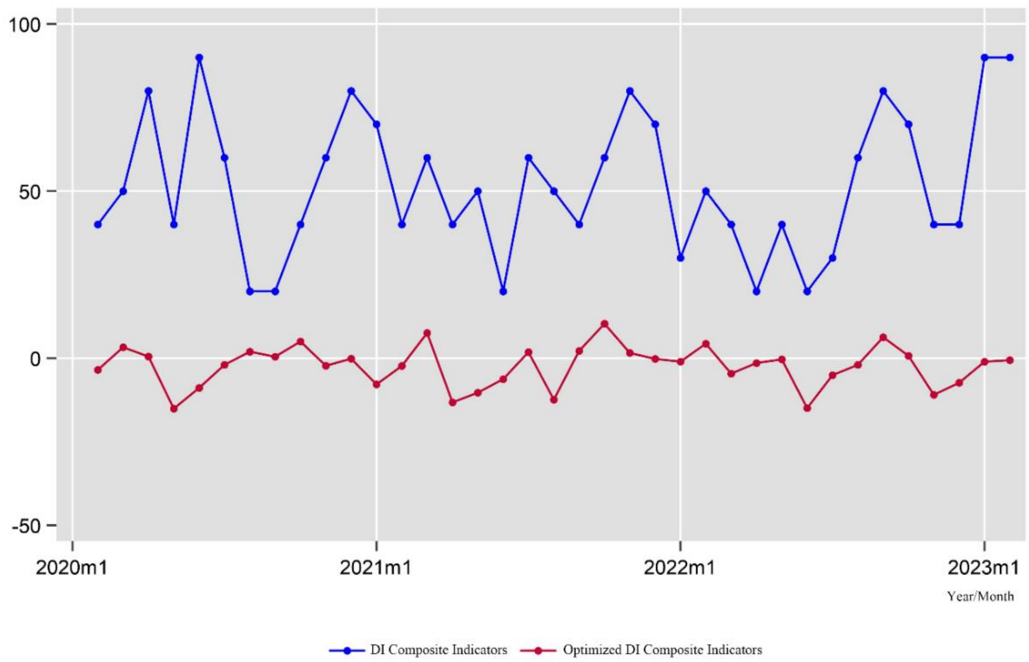


Fig. 5.3 Comparison of Traditional DI and Optimized DI

By comparing the traditional DI and the optimized DI, we can see that the optimized DI is smoother, eliminating the false alarms caused by minor individual jumps in the traditional DI to some extent. In addition, under the larger market fluctuations in 2020, the optimized DI describes market fluctuations more accurately, reflecting a more realistic prosperity change process. However, since the optimized DI incorporates preference operators and changes the original indicative function to a continuous fluctuation intensity function, the impact of indicator changes on the overall prosperity index is weakened to some extent. In the figure, the optimized DI does not have as large fluctuations as the traditional DI, but from a trend perspective, the optimized DI better reflects minor prosperity changes.

5.2 Compilation of the Composite Prosperity Index for China's Refined Oil Shipping Market

The composite index (CI) can describe the economic operation status and the direction of future economic development, reflect the overall degree of economic growth fluctuations, and more accurately represent the amplitude and total amplitude of each wave. After pre-processing the data for seasonal adjustment and synchronization, the average change rate $R_j(t)$ for each group is calculated, and the standardization factor F_j is computed:

Table 5.4 Calculation Results of Standardization Factors

Standardization Factors	F_1	F_2	F_3
Value	0.49207377	1	1.3363259
Average Change Rate	$\sum_{t=2}^{n} \lvert R_1(t) \rvert$	$\sum_{t=2}^{n} \lvert R_2(t) \rvert$	$\sum_{t=2}^{n} \lvert R_3(t) \rvert$
Value	0.0559186	0.11363866	0.15185829

After standardizing the data for each group, the differences between the standardization factors become very small. Therefore, after calculating the leading, coincident, and diffusion groups separately, January 2020 is selected as the base date with its value set to 100. The composite PI for the CROS market from January 2020 to February 2023 is compiled, as shown in Table 5.5.

Table 5.5 Calculation Results of the Composite PI for the CROS Market

Date	**CI** Leading	**CI** Coincident	**CI** Lagging	**CI** Composite
2020m1	100	100	100	100
2020m2	100	100.05	99.6	99.52
2020m3	100.15	100.13	99.65	99.74
2020m4	100.17	100.1	99.62	99.68
2020m5	100.02	100.06	99.56	99.49
2020m6	100.15	100.13	99.57	99.64
2020m7	100.08	100.07	99.51	99.46
2020m8	100.23	100.38	99.78	100.2
2020m9	100.26	100.38	99.78	100.21
2020m10	100.29	100.41	99.81	100.31
2020m11	100.18	100.35	99.74	100.08
2020m12	100.19	100.25	99.65	99.88
2021m1	100.28	100.3	99.69	100.02
2021m2	100.21	100.25	99.63	99.87
2021m3	100.23	100.28	99.63	99.9
2021m4	100.41	99.5	99.01	98.38

2021m5	100.54	99.59	99	98.52
2021m6	100.44	99.54	98.67	97.99
2021m7	100.47	99.5	98.67	97.97
2021m8	100.82	99.78	99.06	98.92
2021m9	100.69	99.32	98.78	98.04
2021m10	100.79	99.47	98.98	98.5
2021m11	100.83	99.5	98.96	98.52
2021m12	100.63	99.41	98.93	98.3
2022m1	100.65	99.59	99.03	98.61
2022m2	100.65	99.58	99.07	98.66
2022m3	100.64	99.61	98.98	98.57
2022m4	100.64	99.54	98.96	98.47
2022m5	100.53	99.5	98.91	98.31
2022m6	100.58	99.51	98.89	98.31
2022m7	100.51	99.49	98.75	98.07
2022m8	100.21	99.31	98.61	97.57
2022m9	100.36	99.45	98.76	97.98
2022m10	99.52	99.06	98.5	96.84
2022m11	99.6	99.08	98.51	96.91
2022m12	99.62	99.12	98.53	96.99
2023m1	99.5	99.06	98.45	96.76
2023m2	99.36	98.97	98.42	96.58

According to the calculation results of the CI, the leading, coincident, lagging, and CI of the CROS market prosperity are shown in Figure 5.4:

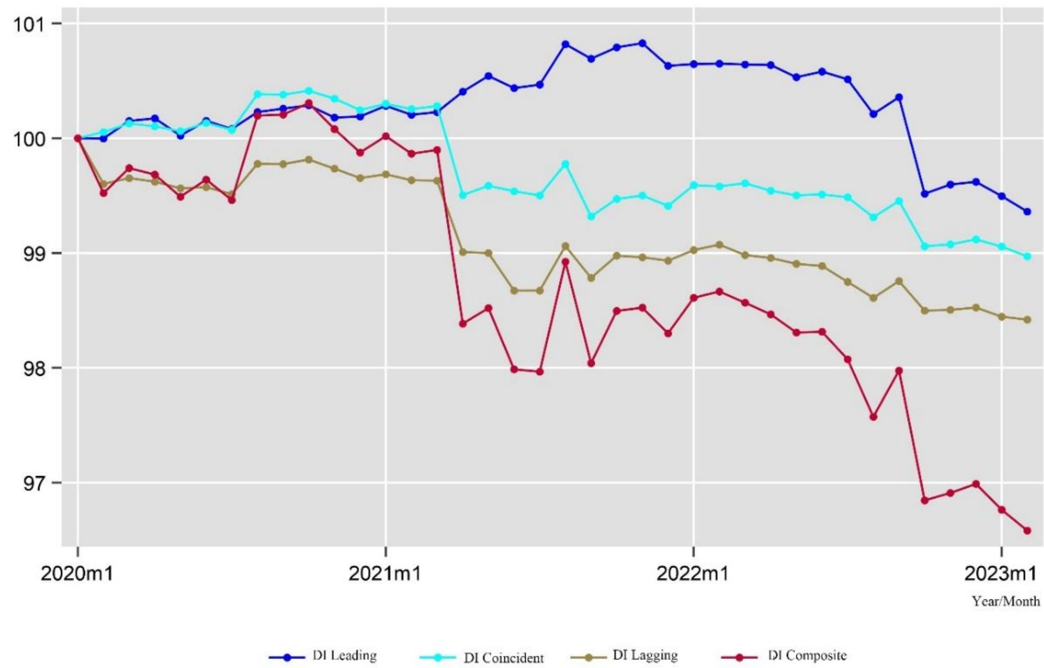


Fig. 5.4 DI Leading, DI Coincident, DI Lagging, and DI Composite

Compared to the traditional DI and the optimized DI, the DI can more clearly display the fluctuations and amplitude of the entire market and can show the amplitude and extent of fluctuations more prominently, effectively compensating for the shortcomings of the DI.

5.3 Empirical Analysis of Prosperity Monitoring in China's Refined Oil Shipping Market

The DI and CI are the two main components of the PI system, with each focusing on monitoring and early warning of prosperity. They can complement each other and have both commonalities and differences. Both can effectively judge the prosperity situation and predict turning points. However, they also have their own shortcomings: the DI cannot grasp the magnitude of prosperity fluctuations, i.e., the extent of fluctuations, while the CI is relatively difficult to determine turning points.

Therefore, combining the two can leverage their respective advantages, with the DI primarily used for judging turning points in the prosperity landscape, belonging to the qualitative analysis aspect, while the CI can be used to compare the degree of prosperity fluctuations, belonging to the quantitative analysis aspect.

As both contain leading, coincident, and lagging indicators, the two sets of indicator systems can be combined for observation: the index synthesized by leading indicators is called the Warning Index (WI), the index synthesized by coincident indicators is called the Monitoring Index (MI), and the index synthesized by lagging indicators is called the Verification Index (VI).

In practical applications, the WI is usually used to predict future prosperity trends, determine whether a turning point will be reached, and predict the time of the next peak or trough. The MI is used to reflect the current operating status and observe whether prosperity is changing. The VI is used to determine whether the peak or trough of cyclical fluctuations has already appeared and to verify and evaluate the effectiveness of the indicator system based on it.

By comprehensively using the characteristics of various indicators and indices, we can more accurately and comprehensively grasp the prosperity changes in the CROS market. By analyzing the development trend of the CROS market in recent years through the optimized DI and CI trends obtained earlier in this paper, the optimized DI shows better trend performance than the traditional DI. In the following empirical analysis, the optimized DI will be used, and the mentioned DI refers to the optimized DI.

- Leading Index

Leading indicators can pre-emptively judge the future trends of the CROS market, making them a powerful tool for short-term economic prosperity analysis. Their characteristics can be used to infer whether the expansion or contraction tail is reached and whether peaks and troughs have appeared. Leading indicators are of great significance for predicting turning points in economic fluctuations.

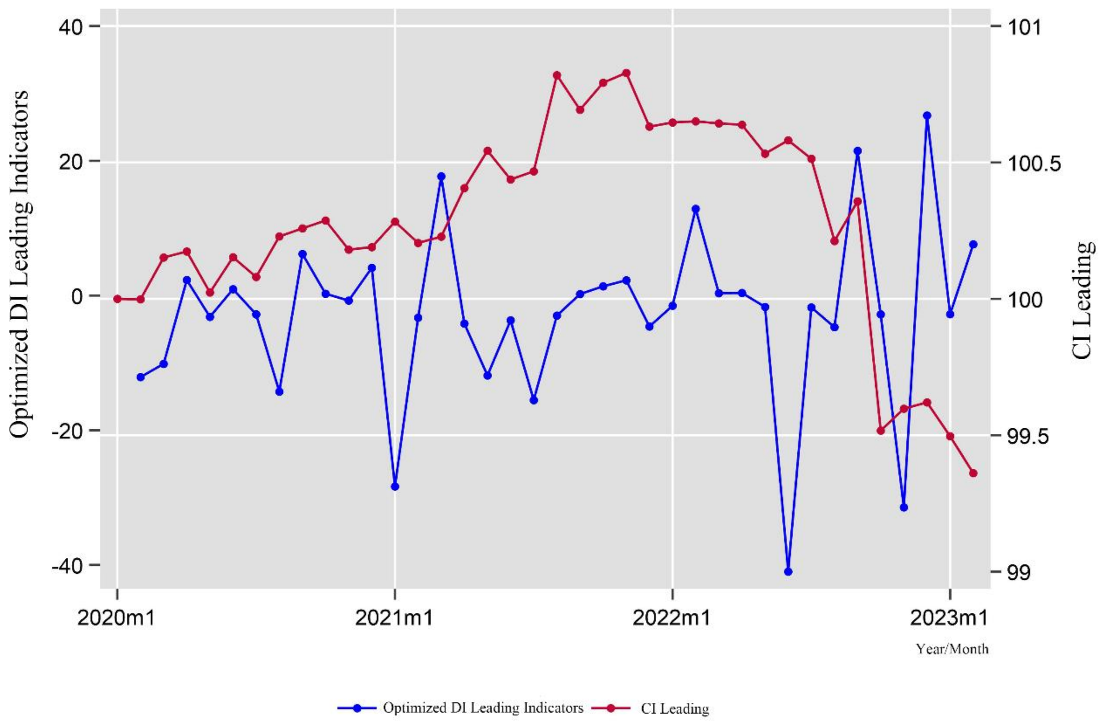


Fig. 5.5 Comparison of Optimized DI Leading and CI Leading

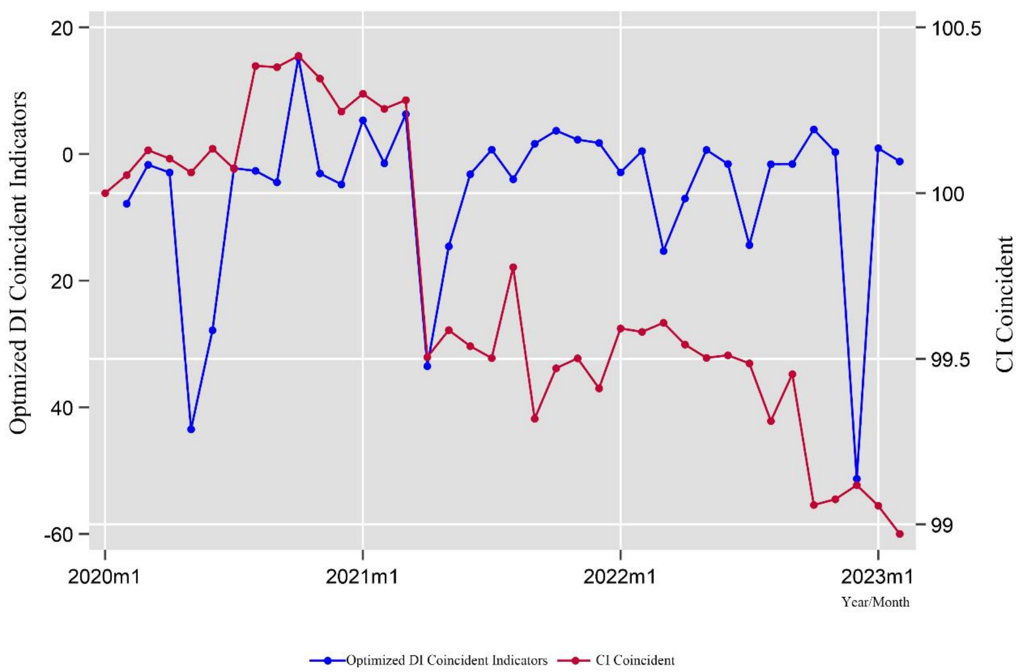
As seen in Figure 5.5, the leading DI operated near the prosperity-demarcation line between January 2020 and February 2022. During the same period, the leading CI also experienced fluctuations after 2020, gradually climbing upwards, and in the second half of 2022, both the DI and CI showed significant fluctuations. It is worth noting that, starting from the second quarter of 2022, leading DI showed signs of a turning point. At that time, the COVID-19 pandemic in China was severe, with important economic cities such as Shanghai experiencing work stoppages and shutdowns, leading to a rapid economic downturn in the short term, decreased market consumption, and a decline in refined oil transportation along the Chinese coast. Company A's transport volume in May was 1.47 million tons, a month-on-month decrease of 18%, and in June, the transport volume was 1.26 million tons, a further month-on-month decrease of 14%.

Taking this stage as a turning point, the leading CI began to decline, and both maintained a downward trend until February 2023. On the other hand, the leading DI showed an upward turning point at the end of 2022, and there was an increase in January 2023, although the CI has not shown a significant rise. However, according to Company A's market analysis, the Chinese economy is expected to improve, and the refined oil market in the second quarter of 2023 will show a continuous recovery.

Although there will be many refinery maintenance events, production is expected to remain stable. In addition, gasoline consumption will remain strong, supported by demand, while diesel will be primarily driven by the stabilization of essential infrastructure and industrial projects. Exports are expected to decline month-on-month, but the foreign trade market situation still needs to be observed. The forecast for gasoline and diesel production is 101.45 million tons, a 5.3% increase from the first quarter, while gasoline consumption is 100.8 million tons, an 8.55% increase from the first quarter. Based on the DI and CI judgments, it is expected that a stable upward channel will be entered in the second half of 2023.

- Coincident Index

The coincident index accurately reflects the current market situation and, in most cases, reaches its peak or trough values consistent with economic fluctuations. It is used to determine the real position of the CROS market's economic activities and



describe the prosperity status at a specific point in time.

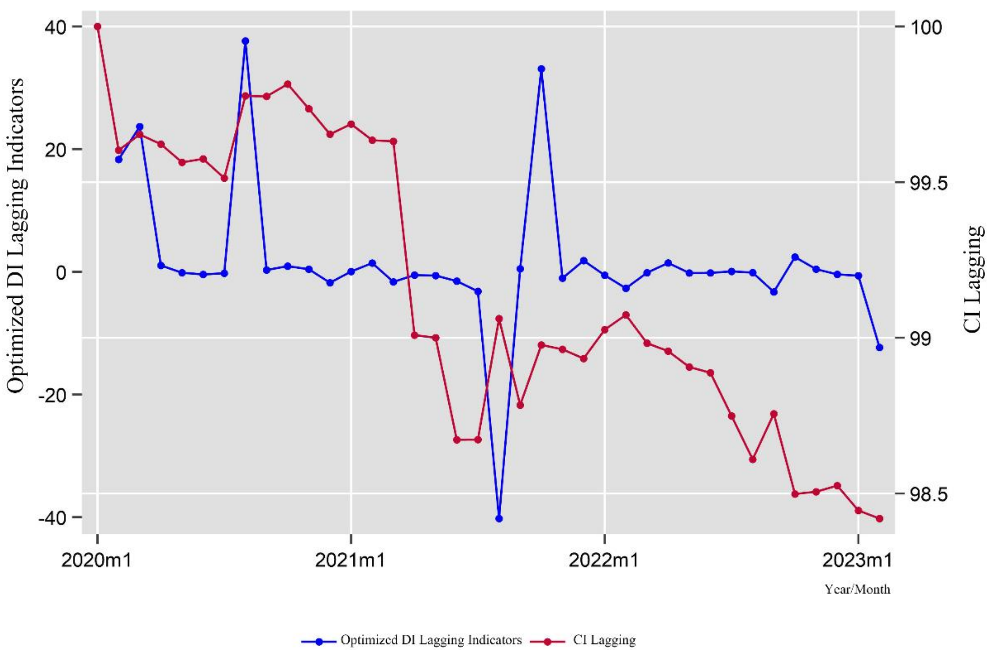
Fig. 5.6 Comparison of the DI Coincident Optimized and the CI Coincident

Looking at the fluctuation trends of the coincident optimized DI and the CI, the market experienced a stable recovery after the severe impact of the COVID-19 pandemic in February 2020. In the first quarter of 2021, Company A's average monthly transport volume was only 1.25 million tons, lower than the average of 1.56

million tons in 2021. However, the DI index remained above the prosperity-demarcation line until the third quarter of 2022, indicating overall market stability. In the third quarter of 2022, the CROS volume increased, but various factors caused a sudden market capacity strain. Taking Company A as an example, the transport volume in November was 1.31 million tons, a month-on-month decrease of 21%, which was clearly reflected in the DI index. At that time, the market environment Company A faced involved changes in China National Petroleum Corporation (CNPC)'s shipping ports distribution configuration, with Jinzhou and Bayuquan's volume of refined oil departure shipments significantly higher than historical averages, exceeding port capacities. Meanwhile, the volume in the Dalian region decreased, and the refined oil grade configuration became imbalanced, resulting in a substantial drop in Company A's ship utilization efficiency and a significant impact on the market.

- Lagging Index

The lagging index appears after actual turning points in China's refined oil transportation market and can be used to confirm changes in prosperity, verify whether the market has reached a peak or trough, or whether it has reached a turning



point and changed its prosperity status, playing a validation role.

Fig. 5.7 Comparison of Optimized DI Lagging and CI Laging

As lagging indicators, the trends of the optimized DI lagging and CI lagging indicators are significantly influenced by the PMI, bunker prices, and crew remunerations. Since February 2020, regulations for seafarers, including quarantine measures, crew change restrictions, and limitations on social contact, have led to increased costs for shipping companies. For example, during the early stages of the COVID-19 pandemic, numerous ships were stranded in ports due to crew change restrictions, which drastically increased operational expenses. Concurrently, bunker costs have surged due to factors such as the Russia-Ukraine conflict and inflation. In March 2022, the International Energy Agency (IEA) reported a sharp increase in oil prices, which can be directly linked to geopolitical tensions and their impact on global energy markets. This increase in oil prices has further contributed to the rising costs of bunkers for shipping companies.

During this period, the CROS market experienced an unprecedented rise in costs and a decline in demand. As a result, the CI lagging primarily exhibits patterns closely connected with lagging indicators, such as PMI, bunker prices, and crew remunerations. Furthermore, the World Trade Organization (WTO) reported a slowdown in global trade growth during the same period, which reflects the adverse effects of these factors on the shipping industry. In summary, various incidents and data sources provide evidence supporting the strong influence of lagging indicators on the trends of the optimized DI composite and CI in the shipping industry.

- Composite Index

Leading, coincident, and lagging indicators each have different roles in predicting economic prosperity. The CI, which includes all three types of indicators, can comprehensively and concisely reflect the operation of the CROS economic system.

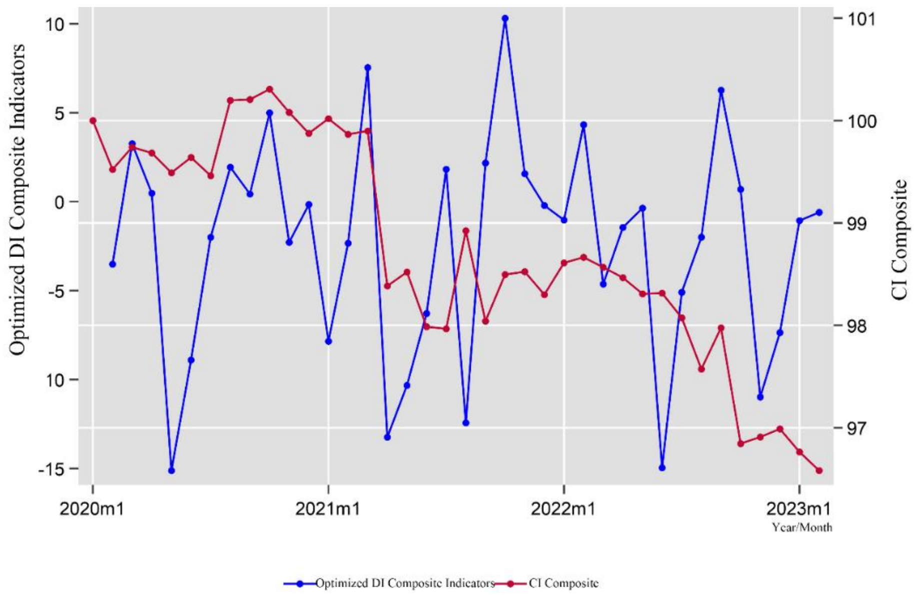


Figure 5.8 Comparison of the Optimized DI Composite and the CI Composite

The figure displaying the significant drop in the CI composite and fluctuations in the optimized DI composite from February 2020 to January 2023 corresponds well with the trends observed in China's refined oil market. This correlation can be substantiated through trend analysis, incident explanations, and demonstrations previously mentioned. The decline in the CI composite coincides with the global economic downturn and disruptions in trade caused by the COVID-19 pandemic, which affected China's refined oil market as demand for oil products diminished. The restrictions on crew changes and limitations on social contact, along with escalating bunker prices contributed to the financial strain on the industry, explaining the fluctuations observed in the optimized DI composite. The demonstrations previously listed, such as the sharp increase in oil prices reported by the IEA and the slowdown in global trade growth according to the WTO, support the correlation between the CI composite's decline and China's refined oil market, further validating the impact of lagging indicators like PMI, bunker prices, and crew remunerations on the trends of the optimized DI composite and CI in the shipping industry.

By observing the fluctuations in China's refined oil transportation market PI, we can draw the following conclusions about the trends in the CROS market in recent years:

The analysis of the diffusion and composite indices shows that the PI of the CROS market is generally consistent with the actual development of the CROS market. The CROS market PI system is relatively effective in monitoring and analyzing market prosperity fluctuations, demonstrating a certain level of scientific and accurate assessment.

CHAPTER 6
CONCLUSION AND OUTLOOK

This study aims to explore an integrated index that reflects the domestic coastal refined oil shipping market from the perspective of prosperity indices (PI). The paper has selected the general diffusion index (DI) and composite index (CI) models by drawing on the methods of domestic and international business cycle judgment and the construction of prosperity indices for various types of ships in the shipping industry. The models have been partially adjusted and improved to better align with the reality of domestic coastal operations. This dissertation first explores the main influencing factors of the domestic coastal refined oil shipping market from the perspectives of supply, demand, prices, and costs. It constructs an indicator system for the coastal refined oil prosperity index and determines factor weights through expert scoring.

Simultaneously, the study adopts the calculation principle of the K-L information amount method and combines the actual situation and expert scoring to categorise the fundamental indicators into leading, coincident, and lagging indicators. After performing data cleaning, seasonal adjustment, synchronisation of trends, and dimensionless pre-processing, the study ultimately calculates and compiles traditional DI, optimised DI, and CI for the coastal refined oil shipping market in terms of leading, coincident, lagging, and comprehensive aspects.

Compiling and calculating monthly data from January 2020 to February 2023 and conducting an empirical study on the results shows that the coastal refined oil shipping (CROS) market indicator system has some relatively sound effects. It can provide a general evaluation of the CROS market's prosperity and cyclical fluctuations. This study can offer a unified reference for national government agencies and relevant ministries to understand the market's basic conditions. At the same time, it provides quantitative judgment and decision-making tools for oil dispatchers, shipowners, and agency companies. The study offers scientific data and theoretical support for actual operations and resource allocation, providing prerequisite support for market forecasting and planning.

Due to the relatively closed and monopolistic nature of the domestic shipping market, information, and data resources available in the market are scarce. This study fills the research gap to some extent and enriches the market shipping index system, contributing to the development of the CROS market and the construction of a shipping financial analyse system. However, due to data scarcity and time constraints, some issues still need to be solved for future academic research and practical exploration. There are three main areas where future expansion and optimisation could be focused:

- Since the data series adopted is limited in length, the final PI compilation is from January 2020 to February 2023. Although it can reflect the overall trend and cyclical fluctuations of the coastal refined oil shipping market in recent years, it is quite brief considering the long history of shipping. Therefore, it is possible to reorganise and filter the basic indicators, clean 5-10 years of AIS data through purchase, or remove some non-critical indicators and add new influencing variables to extend the time series, especially the data from crucial time points such as 2015 and 2019, to make the indicator system more comprehensively reflect market fluctuations.
- When establishing the PI system, the CROS market was considered as a whole, without considering secondary transportation within rivers and short-haul transportation within provinces. However, in actual operation, it isn't easy to separate river and provincial transport ships from coastal inter-provincial ships, as mixed-operation models are common. Therefore, it is worth considering a broader and more representative indicator system that encompasses the CROS market in future improvements.
- When establishing the indicator system, the focus was on the overall market situation, and the guidance and direct reference for the future needed to be clarified. However, in the actual decision-making process, government agencies and shipping companies are more concerned with using models to predict the future better scientifically and establish reliable early warning mechanisms. In future extensions, an early warning indicator light output mode can be established to apply the index more conveniently to actual operations and more clearly demonstrate the core role of the index in predictive management.

In conclusion, this study has conducted qualitative and quantitative research and provided trend summaries and predictive solutions for the CROS market by constructing an PI. However, the primary purpose of this article is to inspire further research, hoping that more experts and researchers can fill the academic gaps in the CROS market, strengthen scientific research on China's domestic shipping. And the ultimate goal is to build an economically friendly, environmental sustainability, harmonious coexistence, and intelligent developed shipping industry by understanding and embracing the characteristics and trends with the efforts altogether.

REFERENCES

[1] Adland, R., Cullinane, K. (2006). The non-linear dynamics of spot freight rates in tanker markets. Transportation Research Part E: Logistics and Transportation Review. Vol. 42(3). pp. 211-224.
https://doi.org/10.1016/j.tre.2004.12.001

[2] Albonico, A., Tirelli, P. (2020). Financial crises and sudden stops: Was the European monetary union crisis different? Economic Modelling. Vol. 93. pp. 13-26.
https://doi.org/10.1016/j.econmod.2020.06.021

[3] Azevedo, S. G., Carvalho, H., & Machado, V. C. (2011). The influence of green practices on supply chain performance: A case study approach. Transportation research part E: logistics and transportation review, 47(6), 850-871.
https://doi.org/10.1016/j.tre.2011.05.017

[4] Brisson, M., Campbell, B., & Galbraith, J. W. (2003). Forecasting some low-predictability time series using diffusion indices. Journal of Forecasting, 22(6-7), 515-531.

[5] Brisson, M., Campbell, B., & Galbraith, J. W. (2003). Forecasting some low-predictability time series using diffusion indices. Journal of Forecasting, 22(6-7), 515-531.
https://doi.org/10.1002/for.872

[6] Bruneau, M., Chang, S. E., Eguchi, R. T., Lee, G. C., O'Rourke, T. D., Reinhorn, A. M., ... & Von Winterfeldt, D. (2003). A framework to quantitatively assess and enhance the seismic resilience of communities. Earthquake spectra, 19(4), 733-752.
https://doi.org/10.1193/1.1623497

[7] Carriero, A. Marcellino, M. (2007). A comparison of methods for the construction of composite coincident and leading indexes for the UK. International Journal of Forecasting. Vol. 23(2). pp. 219-236.
https://doi.org/10.1016/j.ijforecast.2007.01.005

[8] Carstensen, K., Heinrich, M., et al. (2020). Predicting ordinary and severe recessions with a three-state Markov-switching dynamic factor model: An application to the German business cycle. International Journal of Forecasting.

Vol. 36(3). pp. 829-850.
https://doi.org/10.1016/j.ijforecast.2019.09.005

[9] Chen, F. E., Zhao, Y. F. (2010). A Study on the Implications of Shipping Indices for the Construction of Shipping Finance Twin Centres. Navigation of China. Vol.33 No.2 100-105.

[10] Chen, J. Research on Early-Warning System of Shipping Market Based on Prosperity Index. (Unpublished master's thesis). Shanghai Jiao Tong University.

[11] Chen, L. (2019). Research on the Construction and Application of the Monitoring and Early Warning System for the Production Service Industry in China. (Unpublished master thesis). Northwest Normal University.

[12] Chen, L. Y. (2004). Economic cycle phase studies. Jinyang Journals. 2004(4). pp.51-54. DOI: 10.16392/j.cnki.14-1057/c.2004.04.012

[13] Chen, L. Y. (2009). An Analysis of Business Cycle Phase of China and Policies. China Circulation Economy. 2009(2). pp. 28-31.

[14] Choi, J. G. (2003). Developing an economic indicator system (a forecasting technique) for the hotel industry. International Journal of Hospitality Management. Vol. 22(2). pp.147-159.
https://doi.org/10.1016/S0278-4319(03)00015-X

[15] Chopra, S., & Sodhi, M. S. (2014). Reducing the risk of supply chain disruptions. MIT Sloan management review.
https://sloanreview.mit.edu/article/reducing-the-risk-of-supply-chain-disruptions/

[16] Christopher, M. and Peck, H. (2004), Building the Resilient Supply Chain, The International Journal of Logistics Management, Vol. 15(2), pp. 1-14.
https://doi.org/10.1108/09574090410700275

[17] Cubadda, G. Guardabascio, B., et al. (2013). A general to specific approach for constructing composite business cycle indicators. Economic Modelling. Vol. 33. pp. 367-374.
https://doi.org/10.1016/j.econmod.2013.04.007

[18] Diebold, F. X., & Rudebusch, G. (1994). Measuring business cycles: A modern perspective. https://www.nber.org/system/files/working_papers/w4643/w4643.pdf

[19] Drechsel, T., Tenreyro, S. (2018). Commodity booms and busts in emerging economies. Journal of International Economics. Vol. 122. pp. 200-218. https://doi.org/10.1016/j.jinteco.2017.12.009

[20] Fan, W., et al. An Overview and Comparison of Seasonal Adjustment Methods. Statistical Research 2006. No.2. 70-73.

[21] Fan, W., Zhang, L., et al. (2006). An Overview and Comparison of Seasonal Adjustment Methods. Statistical Research 2006. No.2. 70-73.

[22] Gao, T. M. (2009). Econometric Analysis Methods and Modelling: EViews Applications and Examples (2nd Edition). ISBN: 9787302200123.

[23] Gao, T. M., Chen, L., et al. (2015). Methods for the Analysis and Forecasting of Economic Cycle Fluctuations (2nd Edition). ISBN: 9787302389095

[24] Gao, T. M., Kong, X. L., et al. (2003). An analysis of research on international economic prosperity. Journal of Quantitative & Technical Economics. 2003.11. pp. 158-161. DOI: 10.13653/j.cnki.jqte.2003.11.035.

[25] Gong, Y. Y. (2005). Research on Macroeconomic Monitoring and Early Warning System Based on Prosperity Index. (Unpublished master's thesis). Wuhan University of Technology.

[26] Guan, H. (2009). A Study of the International Shipping Market for Dry Bulk Cargoes and Its Volatility Cycle. (Unpublished master's thesis). Fudan University

[27] Han, S., Zhang, BS., Tang, X., et al. (2017). The relationship between international crude oil prices and China’s refined oil prices based on a structural VAR model. Pet. Sci. 14, 228–235. https://doi.org/10.1007/s12182-016-0139-9

[28] Han. D.M. Gao, T. M. (2000). Research on Seasonal Regulation Methods Based on Time Series Models. The Journal of Quantitative & Technical Economics. 2000.3. 41-44. DOI: 10.13653/j.cnki.jqte.2000.03.010.

[29]He, S. Y. (2004). Applied time series analysis. Peking University Press. ISBN: 9787301063477. pp. 142-150.

[30] Hensher, D. A., Zhang, Z., & Rose, J. (2015). Transport and logistics challenges for China: Drivers of growth, and bottlenecks constraining development. Road & Transport Research, 24(2), 32–41. https://search.informit.org/doi/10.3316/informit.560558437747420

[31] Huang, X. H (2006). Research Development on Early Warning Subsystem Based on Prosperity Index of Postal Service's Developing. (Unpublished master's thesis). Beijing University of Posts and Telecommunications.

[32] Hunan University. (2008). Synthetic Index Analysis of Chinese Commodity Markets. The Theory and Practice of Finance and Economics.

[33] International Chamber of Shipping. (n.d.). Shipping and world trade. https://www.ics-shipping.org/shipping-facts/shipping-and-world-trade

[34] Kian G. L., Nikos K., et al. (2019). Understanding the fundamentals of freight markets volatility. Transportation Research Part E: Logistics and Transportation Review. Vol. 130, pp. 1-15. https://doi.org/10.1016/j.tre.2019.08.003

[35] Koichiro, T., Masahiro, I., et al. (2012). An equilibrium price model of spot and forward shipping freight markets. Transportation Research Part E: Logistics and Transportation Review. Vol. 48(4). pp. 730-742. https://doi.org/10.1016/j.tre.2011.12.007

[36] Kumar, A. Mallick, S., et al. (2021). Policy errors and business cycle fluctuations: Evidence from an emerging economy. Journal of Economic Behavior & Organization. Vol. 192. pp. 176-198. https://doi.org/10.1016/j.jebo.2021.10.004

[37] Lai. F. P. (2005). Research on the Industry Enterprise Cycle Index and the Demonstration. (Unpublished master's thesis). Jinan University.

[38] Li, C. X., Lan, X.M. (2004). A Study on the Development and Application of the Retail Business Sentiment Diffusion Index. Economic Survey. 2004. No.3 116-118. DOI: 10.15931/j.cnki.1006-1096.2004.03.035.

[39] Li, J. H. (2009). Design and Application of a Sensitive Index of Economic Growth in China. Research on Financial and Economic Issues 2009.1 (No.302) 3-10. DOI: 10.19654/j.cnki.cjwtyj.2009.01.001

[40] Liang, Q. X., Li, S. H. (2003). Economic Prosperity Observation Method. Shanghai Translation Publishing House. ISBN: 9787532730209

[41] LINE, A. O. (2008). Handbook on Constructing Composite Indicators. The Organisation for Economic Co-operation and Development (OECD), Paris, France. https://knowledge4policy.ec.europa.eu/sites/default/files/jrc47008_handbook_final.pdf

[42] Liu, J. M. (2009). Cycle Division of Dry Bulk Shipping Market and Opportunity of Time Charter. (Unpublished master's thesis). Dalian Maritime University.

[43] Liu, S. C. (1996). On the New Phase of China's Economic Cycle Fluctuations. Institute of Quantitative & Technological Economics (IQTE), CASS. 1996. 11. 3-10.

[44] Liu, Z. J. (2009). Research on the Fluctuation and Forecasting of International Dry Bulk Shipping Market Cycle Based on Wavelet Theory. (Unpublished master's thesis). Dalian Maritime University.

[45] Ma, S. (2021). Economics of Maritime Business. Routledge.

[46] Martínez, R., Moreno-Ternero, J. D. (2022). An axiomatic approach towards pandemic performance indicators. Economic Modelling. Vol. 116. 105983. https://doi.org/10.1016/j.econmod.2022.105983

[47] Megna R., Xu, Q. (2003). Forecasting the New York State economy: The coincident and leading indicators approach. International Journal of Forecasting. Vol. 19(4). pp. 701-713. https://doi.org/10.1016/S0169-2070(03)00002-5

[48] Moore, G. H. (1961). Business cycle indicators (Vol. 1). Princeton, NJ: Princeton University Press.

[49] Moore, G. H. (1983). Business cycles, inflation, and forecasting. NBER Books.

[50] Moore, G. H., & Shiskin, J. (1967). Indicators of business expansions and contractions. NBER Books.

[51] Notteboom, T. E. (2006). The time factor in liner shipping services. Maritime Economics & Logistics, 8, 19-39. https://doi.org/10.1057/palgrave.mel.9100148

[52] Qing, Q. (2012). Research on Global Dry Bulk Shipping Market Prosperity Index. (Unpublished master's thesis). Shanghai Jiao Tong University.

[53] Stekler, H. O. (1961). Diffusion index and first difference forecasting. The Review of Economics and Statistics, 201-208.

[54] Stekler, H. O. (1961). Diffusion index and first difference forecasting. The Review of Economics and Statistics, Vol. 43(2). pp. 201-208. https://doi.org/10.2307/1928672

[55] Stock, J. H., & Watson, M. W. (1989). New indexes of coincident and leading economic indicators. NBER macroeconomics annual, 4, 351-394. https://www.journals.uchicago.edu/doi/epdf/10.1086/654119

[56] Stock, J. H., & Watson, M. W. (2005). Understanding changes in international business cycle dynamics. Journal of the European Economic Association, 3(5), 968-1006. https://doi.org/10.1162/1542476054729446

[57] Stopford, M. (2009). Maritime Economics (3rd ed.). Routledge.

[58] Sun, Z. B., Liu, X. D., et al. (2016). A method for constructing the Composite Indicator of business cycles based on information granulation and Dynamic Time Warping. Knowledge-Based Systems. Vol. 101. pp. 135-141. https://doi.org/10.1016/j.knosys.2016.03.013

[59] Tao, C. M. (2015). Analysis of the Features of the Business Cycles in China Based on Indicators and Frequency Band Approaches. (Unpublished master's thesis). Dongbei University of Finance and Economics.

[60] Tsonis, A. A. (2012). Chaos: from theory to applications. Springer Science & Business Media.

[61] Tsouknidis, A. T. (2016) Dynamic volatility spillovers across shipping freight markets. Transportation Research Part E: Logistics and Transportation Review. Vol. 91, pp. 90-111. https://doi.org/10.1016/j.tre.2016.04.001

[62] U.S. Energy Information Administration. (2021, August 26). China is the world's largest oil consumer and importer. https://www.eia.gov/todayinenergy/detail.php?id=48316

[63] United Nations Conference on Trade and Development (NCTAD). (2021). Review of maritime transport 2021. United Nations. https://unctad.org/system/files/official-document/rmt2021_en.pdf

[64] Vafin, A. (2020). Forecasting macroeconomic indicators for seven major economies using the ARIMA model. Sage Science Economic Reviews. Vol. 3. https://doi.org/10.17613/j3b4-h115

[65] Wang, J. M. (2006). Analysis of the Features of the Business Cycles in the Transient China and Studies on the Application of the Monitoring Methods. (Unpublished Doctoral Dissertation). Jilin University.

[66] Wen, D. H. (1989). Introduction to International Economic Indicators. Projections. 1989. No.4. 56-58.

[67] World Shipping Council. (n.d.). The container ship and world trade. https://www.worldshipping.org/about-the-industry/global-trade/the-container-ship-and-world-trade

[68] Ye, Z.Y. (2003). Choice of Normalization and Dimensionless Methods in Multi-Indicator Comprehensive Evaluation. Zhejiang Statistics. 2003(4). pp. 24-25.

[69] Yuan, X. L. (1988). Analysis and Forecasting of Economic Cycle Fluctuations. DOI: 10.19343/J.CNKI.11-1302/C.1988.03.001

[71] Zeng, Q.H. (2000). An analysis of time series analysis and seasonal adjustment methods. Chunqiu statistics. 105(3). pp. 56-58.

[72] Zhang, L.H. (2002). Study on Forecast Model of International Bulk Shipping Market. (Unpublished master's thesis). Dalian Maritime University.

[73] Zhang, W. He, J., et al. (2022). Real-time macroeconomic monitoring using mixed frequency data: Evidence from China. Economic Modelling. Vol. 117 116068.
https://doi.org/10.1016/j.econmod.2022.106068

[74] Zhao, F. J. (2013). The Study of Establishing the System of the Integrated Transport Market Prosperity Index. (Unpublished master's thesis). Dalian Maritime University.

[75] Zhao, J. G. (2005). An early warning model for unemployment based on the diffusion index method. Research on Financial and Economic Issues. No. 264. pp. 81-84.