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The Determinants of Credit Risk in Shipping Bank Loans

Minnie Chey

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Department of Shipping Management

Graduate School

Korea Maritime and Ocean University

Approval Sheet

This dissertation which is an original work undertaken by Minnie Chey in partial fulfillment of the requirement for the degree of Doctor of Philosophy in Business Administration, is in accordance with the regulations governing the preparation and presentation of dissertation at the Graduate School in Korea Maritime and Ocean University, Republic of Korea.

Approved by Dissertation Committee:

Prof. Dong-Keun Ryoo
Chairman

Prof. Jai Min Lee
Member

Prof. Seongsoon Cho
Member

Dr. Heesung Yun
Member

Prof. Kihwan Lee
Member

Department of Shipping Management
Graduate School of Korea Maritime & Ocean University

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한국해양대학교 대학원, 해운경영학과

요 약

선박금융에 대한 은행의 지원액은 오랜 기간 동안 주식, 채권 등 자본시장 대비 높은 비중을 유지해 왔다. 2008년 금융위기 이후 선박금융 시장에서 차지하는 은행 비중이 감소하였으나, 자본시장의 주식이나 채권 대비 은행의 비중은 여전히 높은 편이다. 은행의 선박금융 공급액은 해운 사이클에 따라 변동해 왔으나, 최근 10년 동안 선박금융시장에서 나타난 흥미로운 점은 상위 40개 글로벌 선박금융 은행 순위가 크게 변동한 것이다. 즉, 해운 불황 지속 및 Basel III 도입으로 인한 은행 자본 및 자산에 대한 규제 강화 등으로 선박금융의 전통적 강자인 유럽계 은행의 지원금액과 비중이 큰 폭으로 감소하였다. 특히, 자국 컨테이너 선대를 집중 지원해 온 독일은행들의 대규모 손실로 상위 40개 선박금융 은행 중 유럽계 은행의 비중은 2010년 83%에서 2018년 59%로 감소하였다. 반면, 아시아계 금융기관의 비중은 같은 기간 중 15%에서 35%로 증가하였다[1]. 이에 본 연구는 글로벌 시장에 선박금융을 제공하고 있는 아시아의 A은행의 자료를 활용하여 선박금융 대출의 신용리스크에 영향을 미치는 요인들을 분석해 보고자 하였다.

[1] Petrofin Research, 2019.

본 연구에서는 선박금융 신용리스크에 영향을 미치는 주요 요인으로 기존 논문과 실무에서 사용되는 변수들을 선정하여 지원조건(loan-specific variables, 차주특징(firm-characteristics variables), 재무특징(financial-characteristics variables), 해운시황(market risk variables) 변수들로 구분하였다. 그리고, 2003년부터 2018년까지 A은행에서 지원한 글로벌 선박금융 데이터 112건을 상선에 대한 샘플 I(93건)과 상선 및 해양플랜트를 포함한 샘플 II(112건)로 구분하여 회귀분석을 수행하였다. 종속변수는 차주의 신용리스크를 반영한 가산금리(margin)로 선정하였고, 선박금융에 영향을 미치는 4가지 주요 요인 별로 4개의 모형(M1~M4)과 종합모형(M5)으로 구분하여 총 5개의 모형을 통해 선박금융 신용리스크 결정요인을 분석하였다.

실증분석 결과(M5), 샘플I의 경우 2개의 지원조건 변수(CDS 스프레드, 원리금상환계수), 1개의 차주특징 변수(선대규모), 3개의 해운시황 변수(글로벌 선대 대비 발주량, ClarkSea 지수, 원유가격)가 통계적으로 유의한 것으로 나타났다. 반면, 샘플II의 경우 2개의 지원조건 변수(CDS 스프레드, 원리금상환계수), 3개의 재무변수(채무감당비율2, 채무감당비율4, 수익성비율) 및 3개의 해운시황 변수(글로벌 선대 대비 발주량, ClarkSea 지수, 원유가격)가 유의한 변수로 나타났다.

본 연구의 결과는 첫째, 해운시황이 선박금융 신용리스크에서 가장 중요한 요인이라는 기존 문헌의 결과를 재확인해 주었다. 둘째, 선박금융을 심사할 때 차주의 신용리스크, 현금흐름 리스크 및 해운시황 리스크는 선종과 관계없이 공통적으로 고려해야 되는 리스크 요인임을 시사한다. 셋째, 상선과 해양플랜트 선박금융에 대한 리스크 분석의 가장 큰 차이점은 차주의 재무적 역량의 상대적 중요성에 있다. 실증분석 결과(M5)에서 상선으로만 구성된 샘플I의 경우 단 1개의 재무 변수도 유의하게 나타나지 않은 반면, 상선과 해양플랜트로 구성된 샘플 II의 경우 3개의 재무 변수들이 유의한 변수로 나타났다. 즉, 중장기 용선계약을 토대로 운영

되는 해양플랜트에 대한 선박금융의 경우 해운사의 재무역량이 중요한 요인으로 나타난 것은 채권보전 수단으로 용선계약의 유용성에 한계가 있다는 것으로 해석될 수 있다.

결론적으로, 본 연구의 결과는 은행들이 상선과 해양플랜트에 대한 리스크 분석을 차별화할 필요성을 시사하고 있다. 특히, 상선은 해운시황 리스크를, 해양플랜트는 해운시황 리스크와 해운사의 재무역량 리스크를 중심으로 한 리스크 분석 수행의 중요성을 제시했다는 점이 본 연구가 선박금융 신용리스크 연구에 가장 크게 기여하는 점이라고 할 수 있다

이 연구의 한계는 다음과 같다. 첫째, 자료의 성격이 pooled cross sectional data로 종속변수와 독립변수들 간의 인과관계의 크기에 대한 time-specific effect의 영향 유무에 대한 회귀분석을 수행하였으나, 자료 수의 부족으로 해당 모형의 경우 통계적으로 유의한 변수가 나타나지 않았다. 또한, 부도 건수의 제약으로 기업신용평가에서 많이 사용되는 로지스틱 회귀분석을 수행하지 못하였다. 향후 부도 자료를 포함하여 자료가 더 많이 축적될 경우 보다 다양한 방법론을 활용하여 본 연구 결과의 일반화를 시도해 볼 수 있을 것으로 판단된다. 그럼에도 불구하고, 이번 연구의 결과는 다양한 국적의 해운사 및 선종으로 구성된 종합적인 포트폴리오를 보유한 금융기관의 선박금융 신용리스크 평가 및 관리에 유용하게 활용될 수 있다. 뿐만 아니라 은행의 선박금융을 필요로 하는 해운기업들의 의사결정 과정에도 도움이 될 것으로 판단된다.

핵심어: 신용리스크, 신용 스프레드, 선박금융

The Determinants of Credit Risk in Shipping Bank Loans

Minnie Chey

Department of Shipping Management
Graduate School of
Korea Maritime and Ocean University

Abstract

Shipping bank loans have long been considered as the main source of financing for the shipping industry. Lower cost, relatively easy access and availability, and long-term relationship banking are some of the reasons for its popularity. The last ten years, however, have brought significant changes to the shipping finance landscape. Although bank loans are still the primary source of financing in shipping, their share declined primarily due to capital constraints imposed by Basel III regulations and heavy loan losses of shipping loan portfolios. According to Petrofin Research, the top 40 shipping banks provided $301billion to the shipping industry in 2018, the lowest since 2010. In addition, the composition of major shipping banks has changed during the last decade. A number of European shipping banks have either reduced their shipping portfolio or exited the industry, and as a result, the share of European banks dropped to 59% in 2018 from 83% in 2010. Meanwhile, a new group of lenders emerged to fill the funding shortfall. Asian financial institutions, including leasing companies and export credit agencies, have become increasingly essential providers of shipping finance.

Against such background, this study assessed key determinants that influence the credit risk of shipping bank loans by analyzing the shipping loan portfolio of a major financial institution in Korea. The dataset of 112 shipping loans is analyzed with two samples: the sample I consists of commercial vessels and sample II consists of commercial vessels and offshore plants. Using regression, the study investigates which of the variables on loan-specific factors, firm characteristics, financial characteristics, and market risk influence the credit risk of shipping loans. Margin, the dependent variable, was used as the proxy variable of credit risk.

The results show that two samples have some common as well as different findings. In both samples, market risk is found to be the most important variable, confirming the results of the existing literature on the credit risk of shipping loans. The study also indicates that banks need to pay more attention to analyzing borrower's financial capacity when financing offshore facilities. None of the financial variables are found significant in sample I (commercial vessels), while three financial variables are found significant in sample II (commercial vessels and offshore facilities). The key finding of the study is that commercial vessels and offshore facilities require a different approach in risk analysis of shipping bank loans. In line with existing literature, the market risk is the most important risk factor in shipping loans to commercial vessels, and market risk and financial capacity of the borrower are important risk factors in shipping loans to offshore facilities. The empirical findings would contribute to better understanding the risk characteristics of shipping loans and enhancing the overall risk management capacity of shipping banks with international clients comprising a diverse range of commercial vessels and offshore facilities.

Lack of shipping loan data is a major constraint in using various methodologies such as logistics regression and neural network. With more data on shipping loans, in particular default loan data, future studies could enhance the generalizability of the research findings. With more

available data in shipping bank loans, it is expected that more advanced methodologies such as panel data regression analysis could be utilized in analyzing the credit risk of shipping bank loans in future research.

Keywords: Credit risk, Credit spread, Shipping loans

CHAPTER 1 INTRODUCTION

1.1 Background

In shipping, banks are the primary providers of capital, lending roughly 75% of the industry's annual financing requirements during 2007~2017 (Alexandridis et al., 2018). The fleet growth during the last super shipping cycle of 2003~07 was financed mainly by the European banks (Kavussanos and Visvikis, 2016). Since the financial crisis of 2008, however, the share of European banks in shipping finance has been significantly reduced primarily due to heavy loan losses and new financial regulations. The extended market down forced several prominent shipping banks in Europe to sell a substantial amount of their portfolio as part of restructuring efforts. More stringent banking regulation of Basel III further pressured banks to downsize their shipping loan portfolio, considered relatively risky under the new rules.

Meanwhile, in Asia, financial institutions in Asia have gained prominence as new suppliers of shipping finance during the last ten years. In particular, banks and leasing companies in China and Korea have provided a significant amount of financing to the industry. These countries are also major shipbuilding nations. In 2010, European banks accounted for 83% of the top 40 banks, but their share fell to 59% in 2018 The funding shortfall was filled by Asian financial institutions whose exposure to the industry increased from 15% in 2010 to 35% in 2018.[2]

Against such background, the key question that motivated this research was to investigate the important drivers of credit risk faced by the new players of shipping finance in Asia. The 2008 financial crisis revealed that underestimating or ignoring credit risk leads to catastrophic

[2] Petrofin Research, 2019.

losses on a global scale. With financial institutions in Asia offering shipping finance on new terms and conditions, it is imperative that we understand the credit risk of these new lenders to ensure that the source of the most critical liquidity in shipping is sustained.

Due to data constraints, academic research in shipping finance has been severely limited to date. Moreover, the available research in this area is concentrated almost entirely on the loan portfolio of European shipping banks. This paper attempts to address the research gap in this field, focusing on the credit risk of shipping loans of a major financial institution in Asia.

1.2 Research Purpose

The objectives of this paper are as follows:

- To identify the key factors that influence the credit risk of shipping bank loans
- To enhance the risk management capacity of financial institutions with an international shipping finance portfolio

1.3 Research Scope

Analyzing the factors that affect the credit risk of shipping loans is the focus of this research. The ordinary least squares (OLS) regression model is employed as the methodology. The relationship between the credit spread and 19 explanatory variables is empirically investigated in two different samples.

Lack of sufficient data is a problem in enhancing the generalizability of the regression results. With more data on shipping loans available in the future, other methodologies such as logistics regression could be adopted to investigate the drivers that influence the probability of default in shipping loans.

1.4 Contribution

- A unique dataset of 112 shipping bank loans of a major financial institution in Asia is utilized to empirically investigate the determinants of credit risk. Compared to previous studies, the dataset used in this research represents an international shipping finance portfolio with broader coverage of financial products, vessel types, shipping companies, and loan period (2003~2018).

- Credit risk determinants between two different sub-sectors (commercial vessels[3] and offshore facilities[4]) in shipping are compared. The results suggest that there are some common as well as different drivers of credit risk between the two samples.

- Credit risk of shipping loans are examined with variables from previous literature as well as risk drivers actually employed in shipping loan appraisals. This would contribute to a better understanding of credit risk in shipping bank loans.

1.5 Structure of the Study

The paper is organized as follows. Chapter 2 outlines the recent evolution of shipping finance landscape from demand and supply aspects, key shipping finance risks, credit risk definition and credit risk models. Chapter 3 reviews the relevant literature on the topic. Chapter 4 describes the data and methodology. Chapter 5 presents the results of the regression analysis and discusses the main findings. Chapter 6 ends the paper with conclusions, limitations, and suggestions for further research.

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[3] In the study, commercial vessels are defined as cargo fleet which include bulk cargo fleet (bulk carriers and tankers), general cargo fleet (containership, Ro-Ro, and other general cargo), and specialized cargo fleet (chemical tankers, LPG, LNG).

[4] In the study, offshore facilities are defined as non-cargo fleet which include drillship, semi-submersible, platform supply vessel (PSV), floating storage regasification unit (FSRU), and floating production storage and offloading (FSPO).

CHAPTER 2 SHIPPING FINANCE AND RISKS

2.1 Shipping Finance Landscape

2.1.1 Demand

According to Stopford (2009), there are four closely interrelated markets in the shipping market, namely the freight market, the shipbuilding market (newbuilding market), the sale & purchase market (secondhand market), and the demolition market. The freight market generally drives the shipbuilding and sale & purchase markets where the vessels are built and traded. The demand for shipping finance is influenced mostly by the activities in the shipbuilding and sale & purchase market and the freight market (Stephenson Harwood, 2018). These markets have experienced persistent oversupply and low freight rates despite declining fleet growth during the last decade (2010~2019). Continued surplus capacity of world fleet (figure 1) and falling orderbook to fleet ratio (figure 2) have caused the newbuilding price index to remain low since 2010, as shown in figure 3. It is well documented in the literature that freight rate level is one of the important factors affecting ship prices (Alizadeh and Nomikos, 2009). Figures 4 and 5 illustrate this point. The average freight rate between 2010 and 2019 is approximately half the previous period (2000~2009), as shown in figure 4. Secondhand price also remained relatively low during the same period (figure 5).

Many drivers influence the shipping market, such as the global economic growth and seaborne commodity trades on the demand side and world fleet and freight revenue on the supply side (Stopford, 2009). The single most crucial factor that has affected the shipping market over the past decade is the Chinese economy (Kavussanos and Visvikis, 2016). Most notably, the global maritime trade has been negatively impacted by the gradual transition of the

Chinese economy from investment-led growth to consumer spending and services. This policy shift of China is indeed a game-changer for the shipping market, where China is the largest buyer of raw materials and containerized goods[5]. The overall poor performance of the shipping market since 2008 has brought some interesting developments. First, after having experienced a prolonged market downturn, the market is debating whether the current low freight rates would become a structural feature[6]. If the low freight rate is the "new normal" in the industry, the traditional cost savings strategy of shipping companies would not be sufficient to survive long-term[7]. Second, a prolonged period of low return over the past decade has resulted in the restructuring and consolidation of certain segments in the industry. According to UNCTAD, the most notable change occurred in the liner industry, with the total market share of the top 10 container shipping lines increasing from 68% in 2014 to 90% in 2019. During 2016~18, the industry also witnessed a wave of offshore companies applying for bankruptcy following the collapse of the oil price in 2015[8].

Third, the reduced availability of traditional bank debt from European shipping banks has affected the shipping industry as a whole, but most severely, the "second and third-tier" companies. A focus on "top-tier" clients by shipping banks is making these small and medium shipping companies increasingly challenging to access shipping finance[9].

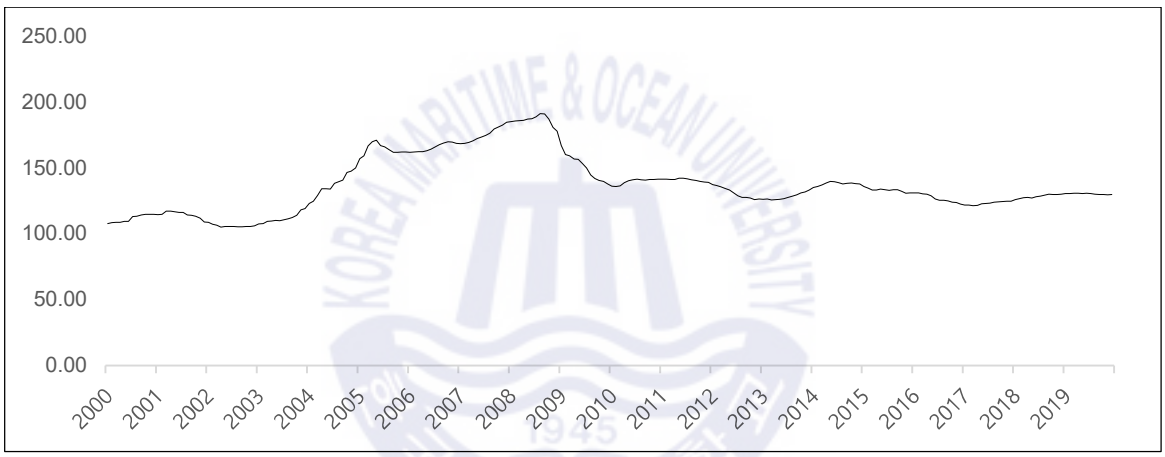
[5] *Review of Maritime Transport 2019*, UNCTAD.
[6] *Shipping Market Review December 2019*, Danish Ship Finance.
[7] Ibid.
[8] *Shipping Review & Outlook August 2019*, Clarksons Research.
[9] Ibid.

Source: Clarksons Research

Figure 1. World Fleet Growth

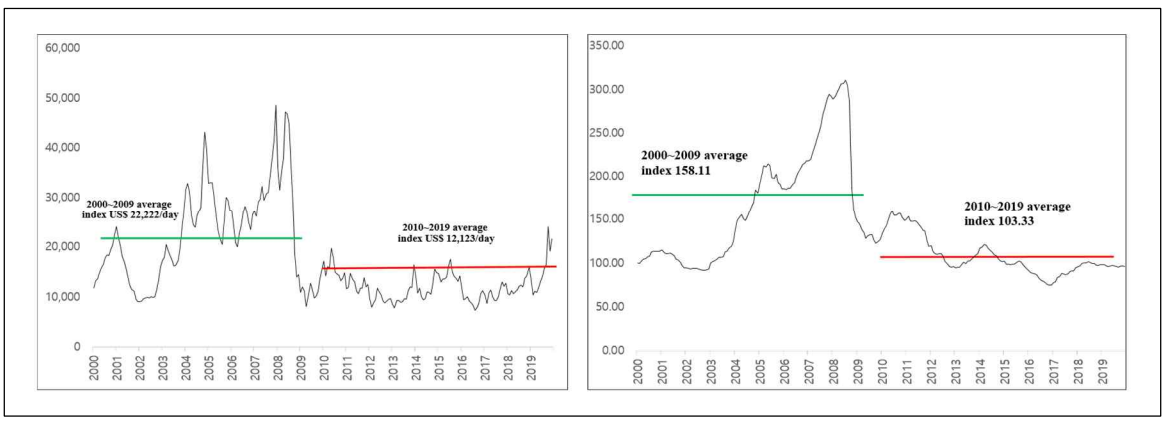
Source: Clarksons Research

Figure 2. Orderbook to Fleet Ratio



Source: Clarksons Research

Figure 3. Newbuilding Price Index



Source: Clarksons Research

Figure 4. Freight Rate

Source: Clarksons Research

Figure 5. Secondhand Price Index

2.1.2 Supply

2.1.2.1 Overview of Shipping Finance

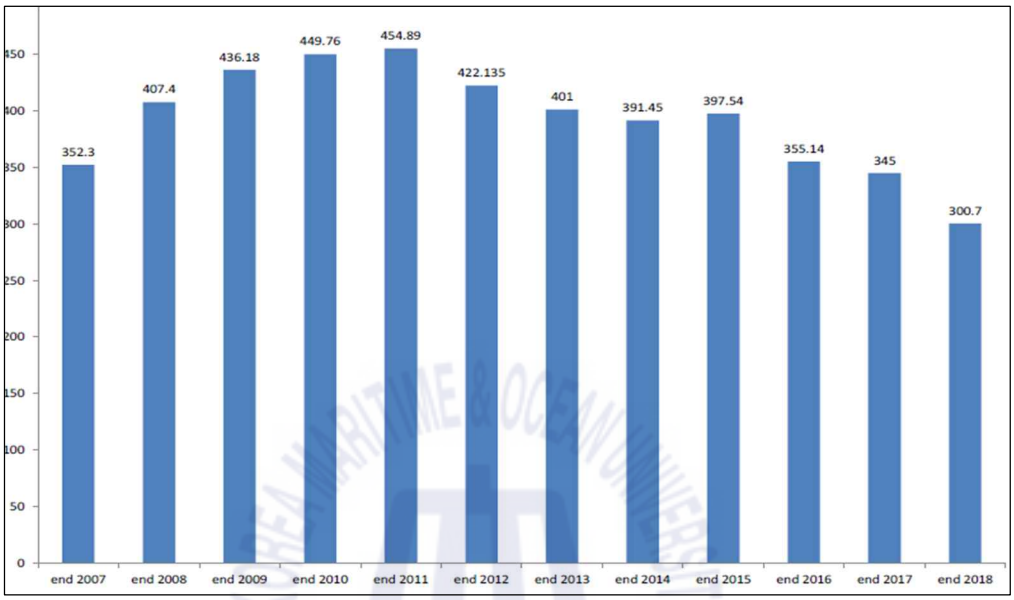
Banks have been the single largest source of financing to the shipping industry for many years. More specifically, banks provided 75% of the industry's annual financing requirement from the period 2007~2017 (Alexandridis et al., 2018). Banks were active during the most recent shipping boom cycle from 2003 to 2007, financing a significant amount of capital at favorable conditions. However, there have been a number of major changes in the shipping finance landscape in the aftermath of the 2008 financial crisis.

First, a combination of extended market downturn and new regulatory requirements led European banks to sell their non-performing shipping assets and restructure their shipping portfolio[10]. Consequently, the amount of financing by the top 40 banks to the shipping companies reduced by 33% to $300 billion in 2018 from $449 billion in 2010, the lowest record in 12 years, as shown in figure 6.

Second, new shipping financing landscape is being defined by new sources of capital and the way vessels are financed. During the last ten years, both financiers and financial products in shipping finance have become increasingly diversified[11]. The funding shortfall created by traditional shipping banks has been met by notably Chinese leasing companies and export credit agencies (ECAs) in Asia. According to Clarksons Research, the combined global maritime portfolio of the Chinese lessors and ECAs is approximately $124 billion in 2019. In addition, a more extensive range of alternative capital, including private equity and mezzanine finance, is now available to shipping companies.

[10] *Shipping Review & Outlook August 2019*, Clarksons Research.
[11] Ibid.

Third, Basel III reforms (2011 & 2017) are expected to put continued pressure on the capital and risk-weighted asset requirements of banks, affecting the number of shipping loans these banks can provide to the industry[12].



Source: Petrofin Research, 2019

Figure 6. Top 40 Global Shipping Bank Loans

2.1.2.2 New Players in Shipping Finance

This phenomenon of bank debt fluctuating with the market cycle and reacting to stricter regulation has happened in the past and is not new in shipping finance. What is surprisingly different this time is that not only the volume of bank financing decreased but the players in the ship financing market changed considerably. As shown in figure 7, in 2010, European banks accounted for 83.1% of the top 40 banks, but their share fell to 58.7% in 2018. This is a very

[12] Binham, C. & Jones, C., 2017. Global rulemakers reach long-awaited compromise on bank measures, *The Financial Times*, 8 December.

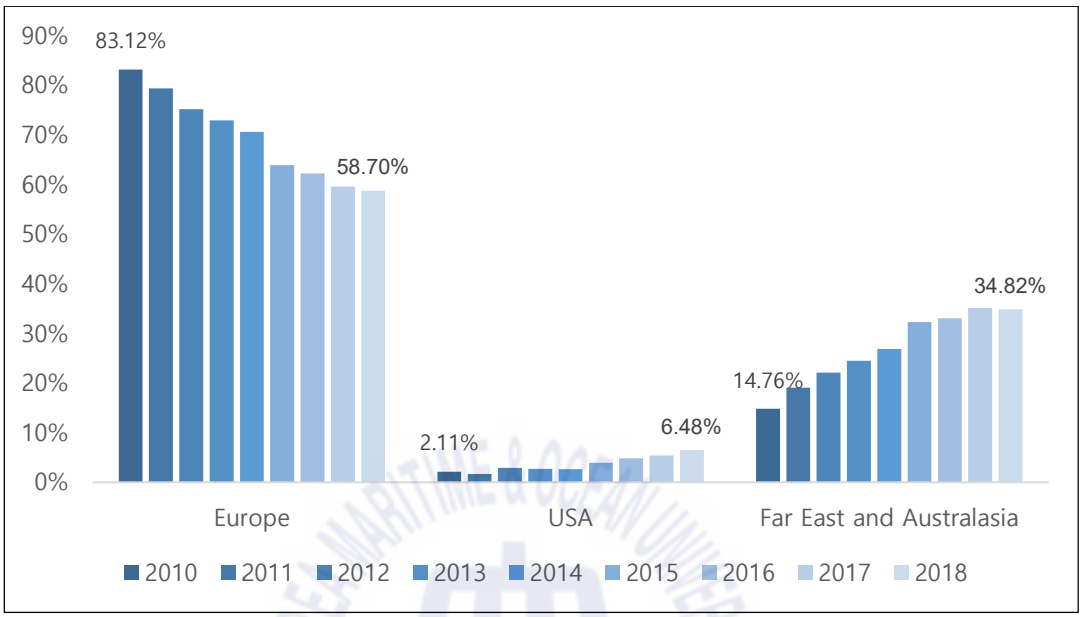
new and interesting development in the history of shipping finance, which has been traditionally dominated by European banks. In particular, the share of German banks in shipping loans declined to 12.6% in 2018 from 34.2% in 2010 according to Petrofin Research.

German banks' prominence in shipping finance rose on the back of the "KG" market, which financed mostly German containership owners through closed-end funds. Long-term charters are essential in getting bank loans to finance the KGs. However, such charters became less available in the market, and banks stopped lending, leading to a collapse of the system[13]. In 2010, According to Petrofin Research, German banks accounted for 34.2% of the top 40 shipping banks, but the figure dropped to 12.6% in 2018. The German banks' aggregate non-performing loan ratio was around 40% at the end of 2017. German banks with significant exposures to the KGs such as Commerzbank, HSH Nordbank, and Nord/LB were severely affected[14]. Commerzbank exited the shipping finance market completely while HSH Nordbank and Nord/LB restructured their shipping portfolio by selling their non-performing loans to private equity funds[15]. Other European banks such as Royal Bank of Scotland and Lloyds Bank have also exited the industry[16].

The funding shortfall caused by the absence of traditional European shipping banks was filled by Asian financial institutions whose exposure to the industry increased from 15% in 2010 to 35% in 2018[17]. The prominence of Asian institutions as essential suppliers of ship financing has gradually grown during the last ten years. In particular, financial institutions in China and Korea provide a significant amount of financing to the industry in which they are

[13] Paris, C., 2018. Germany's commercial shipping fleet shrinks by a third, *The Wall Street Journal*, 23 September.
[14] *Germany's biggest shipping lenders face squeeze on profits as problem loans rise*, Moody's, 06 June 2017.
[15] Paris, C., 2018. Germany's commercial shipping fleet shrinks by a third, *The Wall Street Journal*, 23 September.
[16] *Shipping Review & Outlook August 2019*, Clarksons Research.
[17] Petrofin Research, 2019.

still the major builders of commercial vessels. According to Clarkson Research, China, Japan, and Korea accounted for 95% of the global orderbook in 2018.



Source: Petrofin Research, 2019

Figure 7. Regional Breakdown of Global Shipping Bank Loans

Compared to their European counterparts, several interesting characteristics are observed in these new group of lenders. First, the lenders in Asia come from diverse backgrounds, including banks, export credit agencies, and leasing companies. In particular, many financial institutions in Asia involved in shipping finance are export credit agencies or state-owned banks whose mandate is to support the export of their shipyards. They do this by financing domestic and international shipping companies who purchase vessels from their yards. Notably, Chinese financial institutions have emerged as important players in the international shipping finance landscape. Measures adopted in 2014 to encourage the growth of leasing companies and more importantly, China's Belt and Road Initiative, have helped drive the country's shipping finance

boom[18]. According to Marine Money, Chinese leasing companies provided a total of $34.2 billion to the shipping industry at the end of 2017. In the beginning, Chinese lessors mainly targeted newbuilding in bulk carriers and containerships by top tier companies with strong balance sheets and sizeable fleets. In recent years, however, Chinese lessors have expanded their business model to refinancing and diversified into supporting gas carriers and tanker deals[19].

Second, Asian financial institutions that are active players in shipping finance tend to rely less on relationship banking. Relationship banking is considered an important element in the risk analysis of traditional shipping loans because relationship banking allows banks to assess the otherwise unobservable but crucial management quality of their borrowers through long-standing trust and information-sharing. However, relationship banking is relatively difficult for lenders in Asia. They engage with a more diversified client base, often financing companies in both commercial and offshore sectors from all over the world. Thus, Asian lenders operate under a different business model compared to traditional shipping banks in Europe. To what extent such a new approach of shipping finance has an impact on the credit risk of the shipping portfolio remains to be seen. It would be interesting to continue monitoring such patterns of change in shipping finance.

2.1.2.3 Diversified Sources of Capital in Shipping Finance

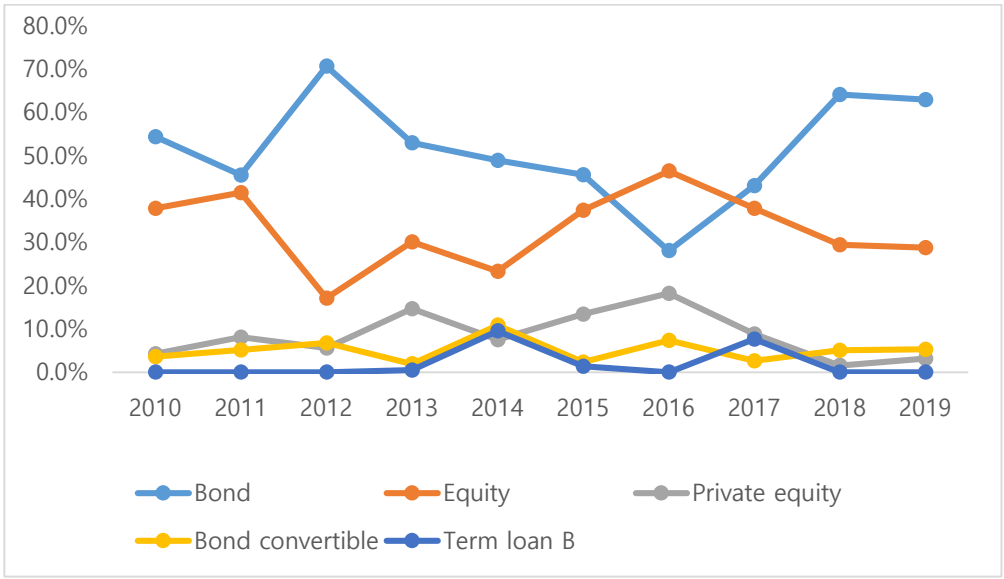
In the absence of shipping loans by European banks, shipping companies have been seeking alternative capital to finance their vessels[20]. Figure 8 illustrates the trend of non-bank debt in

[18] *The rise of Chinese financial leasing*, January 2017, Marine Money.
[19] *Shipping Review & Outlook August 2019*, Clarksons Research.
[20] Ibid.

shipping finance from 2010~2019. According to Marine Money, bond and equity together account for 72.1% (2014) to 93.4% (2018). Except for one single year (2016), the bond has maintained its share in the non-debt capital above 40% during the last ten years. In 2012, the share of bond issuance reached its maximum (70.6%). Ultra-low interests increased the use of Master Limited Partnership (MLP) structure by the US shipping companies. The growth of Norwegian high-yield bond market also contributed to the popularity of bond issues. Meanwhile, the shipping IPOs never recovered after its peak ($27.6 billion) in 2007. The shipping equity deals during 2010~2019 were mainly equity follow-on from publicly listed companies and private placements than IPOs.

It is interesting to note the growth of various alternative capital products such as private equity, convertible bond, and term loan B. During the last ten years, an increased number of shipping projects have been financed by more diverse sources of capital. What would have been considered exotic ten years ago is now a market norm: a shipping loan transaction where Chinese leasing companies and European banks are in the syndication to finance a consortium of Greek and private equity owners. They are building their ships at a Korean shipyard. Financial terms and conditions of shipping loans have become increasingly sophisticated during the last decade.

Beginning in 2011, private equity received much attention, with their share of financing growing more than two-fold from 5.5% in 2012 to 14.6% in 2013. Private equity, commonly in the form of joint ventures with the shipping companies, continued to remain relevant in the shipping finance scene until 2017 before withdrawing from the market from 2018. The share of the convertible bond and term loan B, although fluctuating from year to year, have also complemented the capital shortfall in the shipping finance with their peaks in 2014.



Source: Marine Money

Figure 8. Sources of Non-Bank Debt in Shipping Finance

2.2 Shipping Finance Risks

An analysis of the credit risk of shipping loans require banks to examine three major risks; asset risk, cash flow risk, and corporate risk. The level and focus of analysis will vary according to the primary source of repayment. For example, the analysis will focus on whether the transaction will generate sufficient cash flow based on the details of the charter agreement and credit of the charterer in a loan structured with a long-term charter. In general, banks need to assess at least two, and often all three risk factors in shipping finance transactions (Stephenson Harwood, 2018).

2.2.1 Asset Risk

Asset risk is risks of a loss occurring due to changes in the market value of assets (Albertjin et al., 2011). Many traditional shipping banks consider themselves as asset financiers. However, evaluating market values of vessels is not a straightforward task in a market with a high degree of disaggregation and substantial volatility. In shipping finance, lenders are exposed to asset risk when the vessel is mortgaged as collateral (Bessis, 2015).

The most common measure used is the loan to value ratio (LTV), which is set at 60~80% of vessel value. The LTV formula worked fined during normal times, but the credibility of LTV as a risk indicator was severely damaged in the wake of the 2008 financial crisis (Duru, 2019). The problem began with the mark-to-market approach, which is the most widely used valuation method in the industry. This approach assumes that the market pricing of vessels is correct on average and uses the most recent sale price of a vessel with similar specifications as a reference. This valuation became problematic in the 2008 downturn when representative sales were not readily available. The massive volume of shipping loans was subject to default because they could not pass the minimum value test. From this experience, the lenders learned that such

minimum value clauses and remedies, including prepayment or provision of additional security in the loan agreement, are ineffective during the market downturn.

The mark-to-model valuation was developed to overcome such weakness of the mark-to-market valuation. Under the discounted cash flow (DCF) method, the sum of the discounted operating earnings and future resale value is used to derive the vessel's price. Despite the drawback of the mark-to-market approach, it is still the predominant valuation employed by the banks, with no alternative approach credible enough to replace the mark-to-market valuation. Lessons learned from experience during this period is that there is no right level of LTV, and it has to be considered in relation to historical and current values of earnings (Stephenson Harwood, 2018).

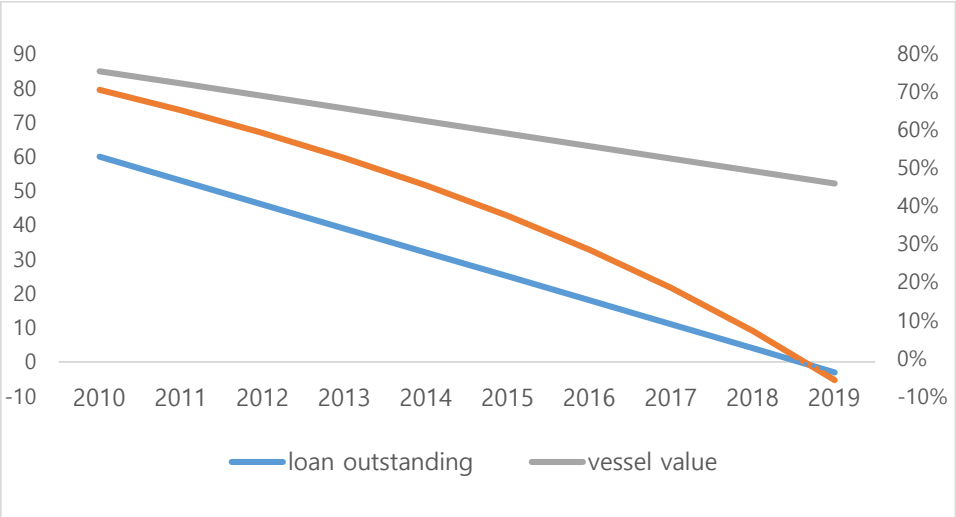
In assessing the vessel's current and future value, lenders also need to understand the drivers and trends that influence the ship prices. Several studies have shown that ship prices exhibit following characteristics: (1) newbuilding prices are more stable than secondhand prices, (2) secondhand ship price volatilities are higher for larger vessels than smaller ones due to operational inflexibility and trading restrictions, (3) secondhand ship prices are more volatile in bulk carriers compared to containerships, and (4) the market values of ships are closely correlated with freight rates, displaying similar volatility.

Lastly, lenders should understand the cyclical nature of the sub-sector shipping market and where the market is situated on the cycle. As we have witnessed in the aftermath of the 2008 financial crisis, global economic growth and its drivers affect the bulk carrier and container shipping sector in opposite directions. For example, mega trends, global innovation cycles, and changing global trade patterns are important variables for forecasting the containership demand. In contrast, the demand for four major commodities from China are key factors in predicting bulk carrier demand. Thus, it is essential to understand the different factors that influence the

demand and supply of subsectors in the shipping industry. In addition, the possibility of a significant decline in the future secondhand value should be taken into account during loan appraisal if lending at the peak of the cycle.

There are several types of residual value analysis that lenders can use to mitigate asset risk (Stephenson Harwood, 2018). First, LTV development analysis shows the time it would take for the leverage to fall below a certain level to ensure the repayment of the loan. Figure 9 illustrates that assuming a 20-year straight-line depreciation of the vessel (VLCC), the LTV of a loan with a repayment of 10 years will fall below 50% in 2014. The loan will be repaid by the end of 5 years, provided that the vessel is sold at 50% of the market price. The lenders would use the LTV development analysis to assess whether the proposed repayment term of the loan is appropriate or needs to negotiate for a more accelerated condition.

However, the LTV development analysis assumes a simple straight-line depreciation and does not consider the historical lows of the vessel price. Thus, lenders need to also compare future loan outstanding to historically low values to judge the percentage of the projected loan outstanding exceeding the vessel value at a given time. Figure 10 is an illustration of asset value risk analysis. The line representing the value of 5-year old VLCC exceeds the outstanding loan amount at year 5 ($68 million) 8 times during a 20-year period. In the LTV development analysis, the loan outstanding reduced to 50% of the vessel value in year 5, however, the asset value risk analysis tells a different story; the probability of loan outstanding being reduced to 50% of the vessel value in year 5 is not always 100%.



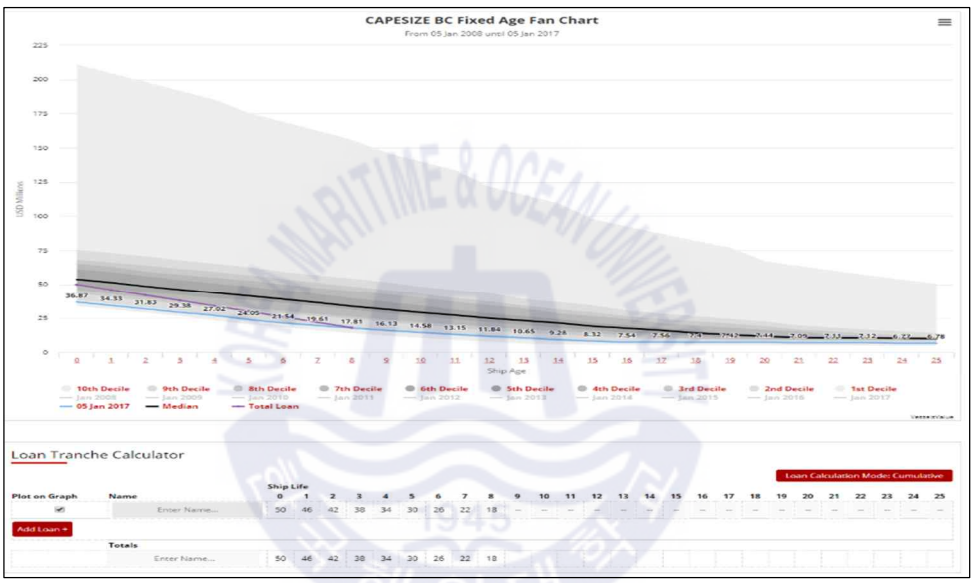
Source: Clarksons Research

Figure 9. LTV Development Analysis

Source: Clarksons Research

Figure 10. Asset Value Risk Analysis

Both LTV development analysis and asset value risk analysis are easy to understand and not very difficult to perform by the banks. For a more sophisticated analysis, lenders can use the service of third-party analysis. Fixed age analysis is a useful tool that allows the analysis of the historical distribution of a given vessel's market values. In figure 11, the price development of a vessel against the loan outstanding of the selected year is displayed, allowing lenders to get a historical perspective of the loan outstanding.



Source: VesselsValue

Figure 11. Fixed Age Analysis

2.2.2 Cash Flow Risk

Cash flow risk is risks of a loss occurring due to changes in the cash flow of the transaction. Fluctuations in the cash flow come mainly from the volatility of freight rate and operating costs and counterparty risk involving the uncertainty of a charterer fulfilling its obligations of the charter agreement.

Freight rate risk is the largest source of risk and major concerns for banks in assessing the

cash flow risk of a shipping project (Stephenson Harwood, 2018). The volatility of freight rate is known to exhibit several characteristics such as extremely high variation greater than those of stocks and bonds, return distribution of kurtosis and negative skewness, and volatility clustering. All these factors contribute to managing the cash flow risk a challenging task for banks. The financial model is commonly used to analyze whether the shipping transaction will generate sufficient cash flow to repay the principal and interest. To assess the viability of the project, the breakeven rate of debt service, the daily sum of operating costs, interest and repayments, is calculated and compared against historic charter rates over a full market cycle of 20 years. To further test the robustness of the cash flow, scenario analysis is conducted to compare breakeven rates with base and low cases for future earnings. The breakeven rate of debt service is sensitive to the repayment profile with equal repayment structure creating lower loan outstanding and lower residual value risk.

The type of employment selected for the vessel affects the revenue of the financial model. In general, lenders prefer shipping transactions with long-term charters because the estimation of future cash flow is considered relatively stable in such projects compared to those based on voyage charter. However, recent evidence has shown that projects with time charters deemed safer in normal times could suddenly suffer from severe negative cash flow during market downturns. That is, time charters are exposed to counterparty risk, which is often ignored during boom periods. In particular, the recent wave of drilling projects that have undergone restructuring or bankruptcy illustrates how sensitive this sub-sector is to fluctuations in oil prices and should be analyzed separately from other sub-sectors.

Grammenos (2010) stressed that banks need to understand the legal documents of time charters to assess the stability of the fixed revenue of the charter and its quality in terms of charterers. Accordingly, the charterer's credit risk and the details of the time charter contract

are important elements in assessing the cash flow risk of a shipping loan whose source of repayment is primarily based on time charter contracts.

2.2.3 Corporate Risk

Corporate risk is risks of a loss occurring due to changes in the borrower's creditworthiness. More specifically, the change in the capacity of the borrower to repay the loan is the focus of corporate risk evaluation.

A number of studies have shown that the Character of the borrower in 6C's of credit analysis is an important element of corporate risk analysis in shipping finance. The Character attempts to measure the borrower's willingness by examining the business strategy, management quality, and experience. The most common criteria for evaluating the management performance are growth in revenues and profits, but what matters is not the absolute rate of return but relative return, which is the return relative to peers and the market. Since shipping companies cannot control freight rates, their performance should be compared with each other under the same conditions. To outperform the peers and the market, the management should excel in running their operations efficiently and deploying the cash generated by those operations effectively. Most management focuses on the former, but the latter is equally important. Deploying capital involves investing in existing operations, acquiring other businesses, issuing dividends, paying down debt, or repurchasing stock. Two companies with identical operating results but different approaches to allocating capital will derive two very different long-term outcomes.

These qualitative dimensions cannot be easily quantified and is often an area of expert judgment. It is also important to note that different business models of the borrower require different elements in the Character analysis. For example, the Character requirement of a borrower in the containership business is different from a Character requirement of a borrower

in the bulk carrier business. This partly explains why relationship banking has become so prevalent in shipping finance.

In shipping finance, ship mortgage and earnings from vessel employment are considered as the main security. However, there are limitations in both sources of repayment as collateral. More importantly, banks cannot rely entirely on the cash flow generated from the project despite being structured as an off-balance sheet stand-alone transaction. This is because the lenders' right is relatively weak in charterparties, exposing lenders to higher counterparty credit risk in shipping finance compared to project finance. In project finance, the duration of the offtake agreement and credibility of the offtakers, among other things, allow the lenders to structure the repayment of the loan entirely reliant on cash flow. In the absence of such a security package, lenders should focus more on analyzing the borrowers' financial capacity and the charterer in transactions with long-term charter contracts.

2.3 Credit Risk

2.3.1 Credit Risk Definition

Banks are inherently exposed to risks in performing the role of a financial intermediary between demand and supply of funds. The business model of banks is based on risk-return mechanisms. Profit is generated for assuming different risk profiles in the financing transaction and banks are compensated for carrying and managing such risks. As banks cannot avoid risk, banks' core function involves sound risk management capacity of identifying, measuring, and managing the key risks.

The Basel agreement identifies three primary sources of risk: credit risk, market risk, and operational risk. Credit risk is the risk of loss resulting from the borrower's default or deterioration of credit status (Bessis, 2015). Credit risk is the largest type of risk that banks

face in their daily activities and has the following set of characteristics: (1) insufficient data on default statistics of the same company makes it difficult to measure the correlation between borrowers. (2) Loss distribution is asymmetrical with a long fat tail, making it challenging to estimate the unexpected loss. (3) Low frequency of default and high amount of loss in the event of default results in large estimation errors of unexpected loss under normal distribution assumptions. (4) Various credit enhancement measures such as guarantee and mortgage complicate the credit risk structure (Baesons et al., 2009).

Credit risk is used interchangeably with the default risk; however, default risk is one of the components of credit risk. Credit risk is composed of three risk factors: default risk, loss risk, and exposure risk. The paper aims to explore specifically the default risk of shipping loans (Baesons et al., 2009).

2.3.2 Credit Risk Models

Credit risk models are categorized broadly into empirical models and financial models (Baesens et al., 2009). Empirical models do not rely on financial theory and estimate credit risk based on historical accounting data such as financial statements. Starting with the Altman's discriminant analysis (1968), empirical models evolved over the years employing more rigorous methodologies. For example, there are statistical methods such as multivariate discriminant analysis, logit, probit, linear probability, and artificial intelligence and machine learning. Although empirical models have been proved to perform quite well, reliance on historical accounting data limits its ability to fully and accurately assess the uncertain and volatile nature of credit risk.

Financial models estimate credit risk based on financial theories such as Modigliani and Miller's capital structure theory and Black-Scholes option pricing theory and use data from

financial markets. The fundamental theoretic framework underlying the financial model is that an overly leveraged firm will fail if unable to generate sufficient earnings (Caouette et al., 2011). Assumptions on the default probability further divide the financial model into the structural model and reduced-form model. In the structural model, default probability is an outcome of the firm value consisting of asset and debt values. In the reduced-form model, the default event is defined as a random stochastic process, and there is no relationship between the default and the firm structure. Jarrow and Turnbull (2000) provide empirical evidence of how market risk variables impact credit spreads in the reduced-form model Structural models provide insight into the determinants of the credit spread (Lepone & Wong, 2009). The Merton model (1974) uses the Black-Scholes option pricing theory to explain that default occurs when the asset value is lower than the face value of the debt and that the pay-off structure to shareholders and bondholders is similar to that of an option pay-off. In addition, the firm's debt can be seen as risk-free debt and a short put option in the Merton model. KMV Credit Monitor was later developed for the commercial application of the Merton model. Despite its strength, it is not easy to use financial models to estimate credit risk in shipping because there are substantial number of private companies without market data such as bond and equity prices.

2.3.3 Basel III Regulations

In response to the 2008 global financial crisis, Basel III framework was revised in 2011 and 2017 to strengthen the financial regulation, supervision, and risk management of banks. The 2011 agreement introduced a higher minimum capital requirement and minimum leverage ratio/minimum liquidity. More specifically, banks were required to establish a minimum core Tier 1 capital ratio to 6% from the previous 4%, and the overall capital ratio increased to 13% from 8%. The major implication of the new framework was the increased cost of capital for

banks and higher loan margins on shipping loans to achieve the same return on equity. The appetite for safer shorter-term assets increased while assets with relatively lower or unrated credit ratings such as shipping loans were deemed riskier.

The 2017 revision aims to increase the risk sensitivity of standardized approaches and to reduce the excessive variability of risk-weighted assets (RWA). According the European Banking Authority, the latest reforms could increase the minimum required capital amount by 24.4%. The impact of the reform will be different depending on the size and complexity of each institution. Global Systematically Important Institutions (G-SIIs) will be affected the most, accounting for 60% of the shortfall in total capital primarily due to the increase of output floor. On the other hand, the capital requirements of small and medium-sized institutions are expected to rise, on average, 5.5% and 11.3%, respectively, mainly due to revisions of the standardized approach to credit risk. In terms of the bank business model, cross-border, local and universal banks in Europe are expected to experience the highest increase in capital requirements (20~25%). Several most prominent shipping banks in Europe, including BNP Paribas (France), Credit Agricole (France), ABN AMRO (Netherlands), Nordea (Finland), DNB (Norway), fall under the category of G-SIIs and cross-border banks.

CHAPTER 3 LITERATURE REVIEW

3.1 General Corporate Finance

In the general corporate finance literature, Altman's Z-score model (1968) pioneered the field on identifying credit risk drivers by employing multiple discriminant analysis. Using data on non-financial US companies, Altman estimated the probability of default based on five financial ratios. These include working capital/total assets, retained earnings/total assets, Earning Before Interest and Taxes (EBIT)/total assets, the market value of equity/total liabilities, and sales/total assets. Following Altman's work, research on identifying the credit risk determinants evolved into different credit risk models based on accounting, market, and macroeconomic variables.

Jimenez and Saurina (2004) analyzed whether specific characteristics of bank loans such as collateral, type of lender institutions, and relationship banking impact the probability of bank loans. The authors examined a dataset of more than three million loans from the entire Spanish banking sector from 1988 to 2000. They find that collateral increases the probability of default, loans by banks controlled by managers are riskier due to adverse selection, and closer bank-borrower relationship increases the banks' willingness to lend to more risky borrowers.

Bonfirm (2009) examined 30,000 Portuguese firm data from 1996 to 2002 using firm-specific financial information and macroeconomic factors to investigate the determinants of credit risk. The results suggest that several firm-specific characteristics such as financial structure, profitability, and liquidity of the firm are important default risk drivers of corporate loans. The author also argues that there is a relationship between macroeconomic developments and credit risk, resulting in excessive risk-taking and strong credit growth during periods of economic growth.

Chang et al. (2009) use a loan dataset consisting of 8,642 loans from a major Chinese state-owned bank from 2003 to 2006 to estimate the effect of financial information and relationship banking in predicting the probability of defaults in loans. The authors find that leverage ratio and cash reserve ratio are significantly related to the probability of default in corporate loans. For borrowers that have long-term relationship with banks, such financial information become more credible and is utilized more extensively in the bank's credit risk analysis. More interestingly, the so-called soft information, the information acquired over a long period of lending relationship with the borrower, is also found significant in explaining the borrower's credit risk, especially when financial information is not reliable.

Bhimani et al. (2014) investigate an extensive bank loan dataset in Portugal from 1997 to 2003 to examine whether a firm-specific factor such as the type of owner liability (limited vs full) influences default risk. The authors also analyzed whether owner liability has a better ability than accounting and non-accounting information in predicting default. The results obtained in the study indicate that the liability status is a useful indicator of credit risk with limited liability firms more likely to default than full liability firms. In addition, the size and age of the firm and financial information, including cash reserve ratio, leverage, and asset coverage ratio, are also important in explaining the probability of default.

3.2 Shipping Finance

Compared to a large volume of literature on the credit risk of general corporate loans, only a handful of studies are conducted on estimating the credit risk of shipping loans. Prior research on the topic can be largely categorized into two groups, primarily based on the relative importance of variables (quantitative vs qualitative) and the methodology employed.

Dimitras et al. (2002) and Gavalas and Syriopoulos (2014) both use the Utilities Additive Discriminates (UTADIS), multi-criteria decision analysis (MCDA) methodology, considered as the appropriate approach in studies of shipping finance with a small sample and a large number of qualitative variables. In particular, UTADIS is known to better capture the knowledge and preferences of the credit risk analysis of banks who rely more on non-financial or qualitative factors including relationship banking. The result indicates that Character/Capacity and Collateral in 5Cs of credit analysis are found important drivers of shipping credit risk.

Dimitras et al. (2002) use UTADIS to examine the default risk of shipping loans. The UTADIS assesses the default risk of shipping loans by estimating the utility function and the utility threshold that classifies a group of shipping loans with minimum misclassification error. A total of 72 financial and non-financial variables proposed by financial consultants are classified into eight major criteria. The sample consists of 17 shipping loan applications from July 1999 to November 2001. The research finds that ownership & management (33.97%), credit history (19.5%), and group/fleet financial characteristics (12.3%) as the most important factors that affect the decision-making in a shipping loan approval. This confirms the authors' hypothesis that qualitative factors are more critical than quantitative factors in the credit risk analysis of shipping loans. Nevertheless, the authors acknowledge that the generalizability of results is constrained by sample characteristics and different sets of pre-defined criteria.

Gavalas and Syriopoulos (2014) also employ UTADIS to assess the relative importance of credit risk factors in shipping loans based on a global bank survey of 12 Greek banks. The result indicates that manager valuation (36.8%) is the most significant criterion, reaffirming the widely held hypothesis that qualitative factors such as shipowner's character/reputation and bank-borrower relationship are the most influential drivers in the default risk of shipping loans.

The authors also find that credit rating grade migration, debt-to-equity ratio, and asset-cover ratio as statistically significant variables in explaining the impact of credit migration on bank credit line facilities.

Dimitiras et al. (2002) and Gavalas and Syriopoulos (2014) contribute to the literature by empirically testing that qualitative factors are the most important drivers of credit risk in shipping loans. However, their research suffers from small datasets and specification errors due to relying on surveys to select explanatory variables.

More recent research such as Mitroussi et al. (2016), Kavussanos and Tsouknidis (2016), and Lozinskaia et al. (2017) use logistics regression, a more common methodology in credit risk assessment and evaluate the relationship between credit risk and shipping loans based on larger samples. The results of these studies are different at the individual level; however, all three studies find market risk as an important driver of credit risk in shipping loans.

Mitroussi et al. (2016) examine the relationship between credit risk drivers and the probability of default and the cost of shipping loans during the financial downturn. The dataset consists of 30 shipping loans granted to the Greek dry bulk sector during the period 2005~2009. The results of their study suggest that both financial and non-financial variables are important drivers of credit risk in shipping loans. In particular, qualitative factors such as shipowner's experience, employability contract, and market sentiment are identified as critical elements during both loan assessment and monitoring period.

Kavussanos and Tsouknidis (2016) analyze the entire Greek shipping loan portfolio consisting of 128 loans from 1997~2011. Their study reveals that the current and expected shipping market (Conditions), the borrower's chartering policy (Character), and arrangement fee (all 6Cs) are the most important factors in estimating the probability of default of a shipping loan. The results of the study are similar to previous research in that "Character" and

relationship banking, are again found as significant variables. What is different, however, is that none of the financial variables were found significant. According to the authors, extreme fluctuations in freight rate make old financial information irrelevant in assessing the credit risk of shipping loans. The authors also argue that credit risk model of shipping banks should incorporate an industry-effect or unique characteristics of the industry.

Lozinskaia et al. (2017) analyze the determinants of the probability of default based on the most extensive dataset consisting of 192 shipping companies in 36 countries. Quantitative variables include the company's market value relative to the book value (Tobin Q), EBITDA, and total assets. The qualitative variables selected were steel price, GDP, and oil price. The results of the study indicate that Tobin Q, GDP, and total assets are found as significant variables, but their effects were smaller than those of previous research.

In addition, two studies focus on the credit risk of shipping bonds. Grammenos et al. (2008) conduct an empirical analysis of 50 high yield bonds issued between 1992~2004. Both financial indicators on liquidity and profitability and non-financial indicators, including industry-specific indicators, are selected as explanatory variables. The results show that gearing, liquidity, cash flow ratios, and industry-specific variables are the main factors contributing to the probability of default in shipping bonds.

Kavussanos and Tsouknidis (2014) examine credit spread changes in shipping bonds from January 2003 to June 2010. Using a dataset of global shipping bonds over an entire shipping business cycle, the authors find the stock market's volatility and the bond market's cyclicality as two new explanatory factors. In addition, the liquidity of the bond issue, freight earnings, and the credit rating of the bond issues are also identified as significant determinants of shipping bond spread changes.

This study contributes to the existing literature by conducting for the first time, an empirical analysis of the credit risk of shipping loans of Asian bank based on its entire shipping loan portfolio. As Alexandridis et al. (2018) points out, the literature on the assessment of credit risk has been limited due to a lack of data. Previous literature in this field relied mostly on a few selected samples or a portfolio of European shipping banks focused mainly on commercial vessels. The dataset used in this study contains (1) commercial vessels and offshore facilities, (2) a wide range of financial products including, loan, guarantee, mezzanine finance and Chinese leasing, (3) both boom and bust periods of the shipping cycle, and (4) borrowers consist of 73 shipping companies from more than 20 countries. The dataset is both unique and representative of recent developments in the shipping finance landscape. Therefore, the results of the study will contribute to better understanding the credit risk of shipping bank loans that have undergone so many transformations especially during the last decade (2010~2019).

CHAPTER 4 DATA AND METHODOLOGY

4.1 Data

The dataset containing 116 shipping loans to 73 companies from 2002 to 2018 was initially selected. Financial data is drawn from the annual audited financial statements of borrowers one year before the commitment date. Four shipping loans with missing financial statements are removed from the dataset. A traditional portfolio of commercial vessels and a more comprehensive portfolio with offshore facilities is divided into two separate samples. This is to compare if there are meaningful differences in factors affecting credit risk between the two portfolios.

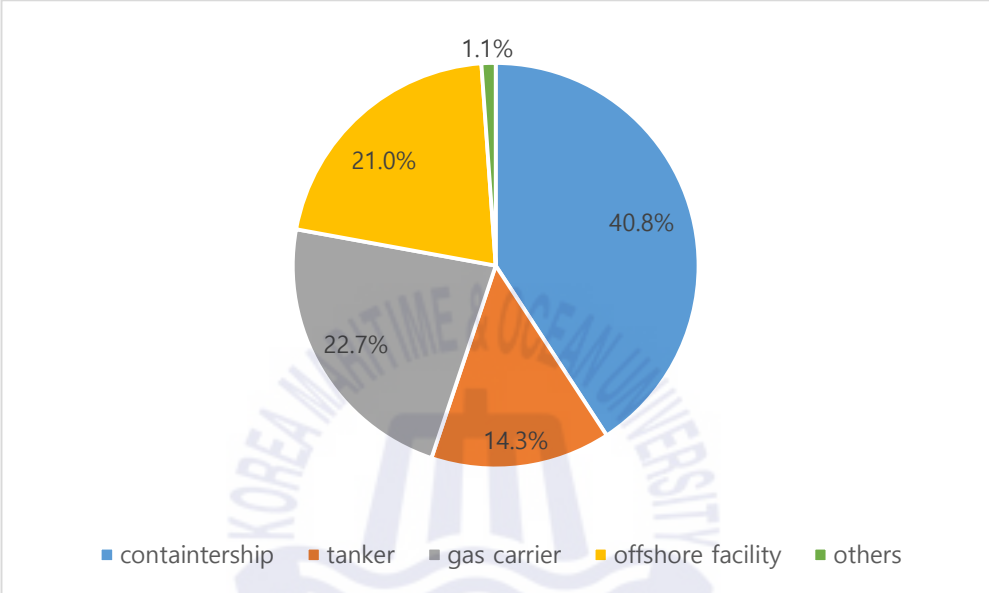
The sample I consists of 93 shipping loans to commercial vessels. In comparison, sample II consists of 112 shipping loans to commercial vessels and offshore facilities.[21] A total of 19 shipping loans to offshore facilities are included in sample II.

The dataset has the following unique features: (1) it is an international shipping loan portfolio of one of the most active shipping banks in Asia. Except for Lozinskaia et al. (2017), previous studies mostly used samples from Greek shipping banks. (2) Both commercial vessels and offshore facilities are included. (3) Time period in the dataset covers all phases of the shipping cycle. (4) All cases in the dataset are financed for newbuilds, and (5) loans and guarantees/insurances are included.

Using sample II, figure 12 presents the vessel profile of shipping loans. Containership accounts for the largest share (40.8%), followed by gas carriers (22.7%) and offshore facilities (21.0%). Gas carriers consist of LPG, LNG and LNG regasification vessel (RV); tankers consist

[21] The offshore facilities in the dataset include drillships, Floating, Production, Storage, and Offloading (FPSO) units, platform supply vessel (PSV), and semi-submersibles.

of VLCC, crude oil tanker, product tanker and shuttle tanker; offshore facilities consist of drillship, semi-submersible, floating storage regasification unit (FSRU), floating storage unit (FSU) and platform supply vessel (PSV); others consist of bulk carrier and pure care truck carrier (PCTC).



Source: Author's elaboration

Figure 12. Vessel Profile of Shipping Bank Loans (sample II)

Tables 1 and 2 present the descriptive statistics of the variables used in the sample I and sample II. Data is cleansed using missing-value treatment and winsorization at 1% and 99% level to reduce the effect of possible outliers.

In sample I, the average CDS spread is 60.78%, ranging quite widely from 13.42% to 151.07%. This may be due to the increase of CDS spread to unprecedented levels during the 2008 financial crisis. The average debt ratio is 0.72 and ranges from 0.49 to 0.90, indicating that the average syndication amount is 72% of the total project cost. However, the banks

provided up to 90% of the vessel price when cash flow generated from the project was sufficient to repay the debt secured by a long-term time charter with a creditworthy charterer. The guarantee ratio ranges from 0 to 0.71, with an average value of 0.14. The level of guarantee in syndication is negotiated between the borrower and the covered lenders who view the project as riskier than other uncovered lenders. The DSCR ratio ranges from 0.96 to 1.94, with an average level of 1.26, suggesting that most of the projects were assessed as having sufficient repayment capacity at the time of the credit appraisal. Other than debt ratio, the three other loan-specific factors exhibit positive skewness, indicating that much of the data have values close to average.

The average age of the firm is 36.60 years, suggesting that the firms in the sample are experienced shipowners. The average fleet owned by firms is 112.80 vessels, with values ranging from 0 to 956 vessels. The kurtosis of the fleet shows that there is a high incidence of outliers in this variable.

The average leverage ratio stands at 0.65, which is moderate considering the capital intensive nature of the shipping industry. Average coverage ratios all exhibit high levels, indicating that the firms in the sample have sufficient profit to cover their current and long-term debt. The average debt coverage ratio4, computed as the interest expenses over EBITDA, is 0.23. This means that shipping companies in the dataset can cover on average, approximately four times their interest expenses through their earnings. Meanwhile, average liquidity ratio2 and the average profit margin ratio are 0.10 and 0.39, respectively. Except for the profit margin ratio, financial characteristics variables are all positively skewed with debt coverage ratio3 and debt coverage ratio1 showing the highest skewness. All financial characteristics variables have a high incidence of outliers with debt coverage ratio3 and debt coverage ratio1 showing the high level of kurtosis.

The average orderbook to fleet ratio is 23.08%, ranging from 11.00% to 49.24%. This is because the sample covers an entire shipping cycle from 2003 to 2018. MSCI index, BDI, and ClarkSea index exhibit high standard deviation while orderbook to fleet ratio, newbuilding index, oil price, and GDP exhibit relatively low standard deviation over the sample period. Market risk variables show moderate skewness while distributions are shorter with thinner tails than the normal distribution in general.

Table 1. Descriptive Statistics (sample I)

	Mean	Median	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis
Loan-specific factors							
CDS spread (%)	60.78	55.99	13.42	151.07	31.43	0.92	0.53
Debt ratio	0.72	0.70	0.49	0.90	0.09	-0.44	-0.57
DSCR	1.26	1.20	0.96	1.94	0.20	1.27	1.57
Guarantee ratio	0.14	0.00	0.00	0.71	0.22	1.35	0.49
Firm characteristics							
Age (year)	36.60	18.00	1.00	179.00	42.05	1.56	1.78
Fleet (number of vessels)	112.80	44.00	0.00	956.00	184.81	3.03	9.64
Financial characteristics							
Leverage ratio	0.65	0.56	0.00	5.25	0.62	4.68	29.93
Debt coverage ratio1	4.18	1.28	-3.24	122.11	14.20	6.69	49.82
Debt coverage ratio2	4.14	3.39	-13.86	26.10	5.46	1.66	7.01
Debt coverage ratio3	41.97	5.51	-19.12	3169.98	328.06	9.32	85.88
Debt coverage ratio4	0.23	0.10	-0.21	1.42	0.29	2.22	5.70
Liquidity ratio1	4.25	1.20	0.09	92.70	12.54	5.15	28.71
Liquidity ratio2	0.10	0.10	0.00	0.61	0.11	2.27	7.22
Profit margin ratio	0.39	0.40	-1.78	1.00	0.37	-2.02	11.08
Market risk							
Orderbook to fleet ratio (%)	23.08	21.00	11.00	49.24	0.09	1.37	1.32
Newbuilding price index	143.95	139.11	119.13	184.83	18.61	0.69	-0.47
MSCI index	1,410.45	1,423.00	858.00	2,052.44	309.78	0.13	-1.12
BDI ($/day)	2,883.44	2,202.80	595.82	9,909.19	2,239.50	1.09	0.73
ClarkSea index ($/day)	21,189.93	18,207.30	8,703.11	45,055.01	10,773.27	0.71	-0.71
Oil price ($/bbl)	63.90	54.43	28.85	111.97	27.00	0.61	-1.04
GDP (%)	4.35	4.28	2.79	5.57	0.91	0.12	-1.69

In sample II, the average CDS spread is 63.66%, ranging quite widely from 13.69% to 203.75%. This may be due to the increase of CDS spread to unprecedented levels during the 2008 financial crisis. The average debt ratio is 0.72 and ranges from 0.50 to 0.90, indicating that the average syndication amount is 72% of the total project cost. However, the banks provided up to 90% of the vessel price when cash flow generated from the project was sufficient to repay the debt secured by a long-term time charter with a creditworthy charterer. The guarantee ratio ranges from 0 to 0.70, with an average value of 0.17. The level of guarantee in syndication is negotiated between the borrower and the covered lenders who view the project riskier than other uncovered lenders. The DSCR ratio ranges from 0.96 to 2.03, with an average level of 1.26, suggesting that at the time of the credit appraisal, most of the projects were assessed as having sufficient repayment capacity. Other than debt ratio and guarantee ratio, the two other loan-specific factors exhibit positive skewness, indicating that much of the data have values close to average.

The average age of the firm is 36.98 years, suggesting that the firms in the sample are experienced shipowners. The average fleet owned by firms is 101.63 vessels with values ranging from 0 to 933.56 vessels. The kurtosis of the fleet shows that there is a high incidence of outliers in this variable.

The average leverage ratio stands at 0.61, which is moderate, considering the capital-intensive nature of the shipping industry. Average coverage ratios all exhibit high levels, indicating that the firms in the sample have sufficient profit to cover their current and long-term debt. The average debt coverage ratio4, computed as the interest expenses over EBITDA, is 0.23. This means that shipping companies in the dataset can cover, on average, approximately four times their interest expenses through their earnings. Meanwhile, average liquidity ratio2 and the average profit margin ratio are 0.09 and 0.07, respectively. Except for debt coverage

ratio3 and profit margin ratio, financial characteristics variables are all positively skewed with profit margin ratio and liquidity ratio1 showing the highest skewness. All financial characteristics variables have a high incidence of outliers with profit margin ratio and liquidity ratio1 showing the high level of kurtosis.

The average orderbook to fleet ratio is 23.10%, ranging from 11.00% to 51.67%. This is because the sample covers an entire shipping cycle from 2003 to 2018. MSCI index, BDI, and ClarkSea index exhibit high standard deviation while orderbook to fleet ratio, newbuilding index, oil price and GDP exhibit relatively low standard deviation over the sample period. Market risk variables show in general moderate skewness while distributions are shorter with thinner tails than the normal distribution.

Table 2. Descriptive Statistics (sample II)

	Mean	Median	Minimum	Maximum	Standard Deviation	Skewness	Kurtosis
Loan-specific factors							
CDS spread (%)	63.66	55.99	13.69	203.75	39.43	1.54	2.62
Debt ratio	0.72	0.70	0.50	0.90	0.08	-0.50	-0.50
DSCR	1.26	1.21	0.96	2.03	0.19	1.65	3.44
Guarantee ratio	0.17	0.00	0.00	0.70	0.23	1.02	-0.34
Firm characteristics							
Age (year)	36.98	18.00	1.11	174.93	41.42	1.45	1.29
Fleet (number of vessels)	101.63	44.00	0.00	933.56	169.49	3.26	11.56
Financial characteristics							
Leverage ratio	0.61	0.58	0.00	2.04	0.38	1.90	5.48
Debt coverage ratio1	3.12	1.23	-5.60	49.87	7.94	4.37	20.93
Debt coverage ratio2	4.62	3.62	-6.09	27.42	5.62	2.21	6.52
Debt coverage ratio3	7.45	6.03	-88.61	56.89	17.15	-2.45	16.20
Debt coverage ratio4	0.23	0.20	-0.28	1.38	0.28	1.94	5.16
Liquidity ratio1	3.40	1.25	0.10	55.60	9.09	4.69	21.74
Liquidity ratio2	0.09	0.10	0.00	0.57	0.10	2.03	5.93
Profit margin ratio	0.07	0.40	-17.82	1.00	2.43	-7.03	48.68
Market risk							
Orderbook to fleet ratio (%)	23.10	21.00	11.00	51.67	0.09	1.28	0.89
Newbuilding price index	143.71	137.82	119.13	184.83	18.36	0.78	-0.34
MSCI index	1,412.15	1,405.00	858.00	2,041.00	302.92	0.14	-1.06
BDI ($/day)	2,775.63	2,190.45	597.00	9,753.07	2,179.66	1.18	0.93
ClarSea index ($/day)	20,302.77	16,155.55	7,861.40	44,578.64	10,526.26	0.80	-0.52
Oil price ($/bbl)	68.27	61.86	28.85	111.97	27.74	0.35	-1.34
GDP (%)	4.24	4.04	0.23	5.57	1.03	-0.72	1.70

4.2 Methodology

The following regression equation is used to estimate the determinants of the credit risk of shipping bank loans:

$$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 X_{2it} + \cdots + \beta_k X_{kit} + \mu_{it} \quad \text{.....Equation (1)}$$

where the margin (Y_{it}) is defined as the credit spread over LIBOR of a shipping loan; i = 1, 2,…, n denotes each shipping bank loan and t =1,2,…,T denotes the time period. X_{kit} (k = 1,2,…,K) denotes the matrix of the K independent variables used to examine credit risk in shipping loans. The ordinary least squares (OLS) regression is estimated for each sample shipping loan i at time t with margin Y_{it}.

The primary reason for using the OLS regression and not logistics regression, which is more commonly used to estimate the credit risk, is a lack of sufficient data. The number of defaulted shipping loans is less than 30 in the dataset that is used for this research. Although several recent studies on the credit risk of shipping loans used logistics regression, OLS regression is also widely used to estimate credit risk of loans in corporate finance literature.

One issue related to the nature of the dataset is the possible presence of heteroskedasticity. Pooled cross-sectional data or a collection of different shipping bank loans over multiple periods produce disparity between different observations in the samples are large with unequal variance in the error term. Both standardized residual analysis and the Breusch-Pagan test suggest the presence of heteroskedasticity in the samples resulting in invalid calculations of confidence intervals and t statistics. Figure 13 and figure 14 also show the presence of heteroskedasticity in the sample I and sample II. Thus, White-Huber-Eicker (1980) robust standard estimator is used to adjust the estimation of standard error of the coefficient estimates. However, the presence of heteroskedasticity does not cause bias or inconsistency in the OLS estimators of the coefficients or affects the interpretation of R^2.

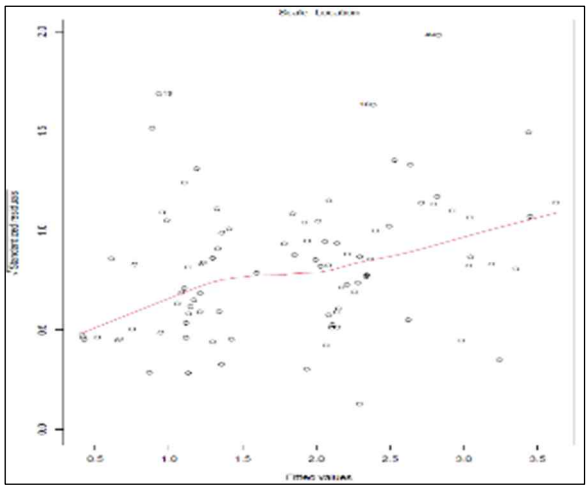


Figure 13. Scale-Location Plot(sample I)

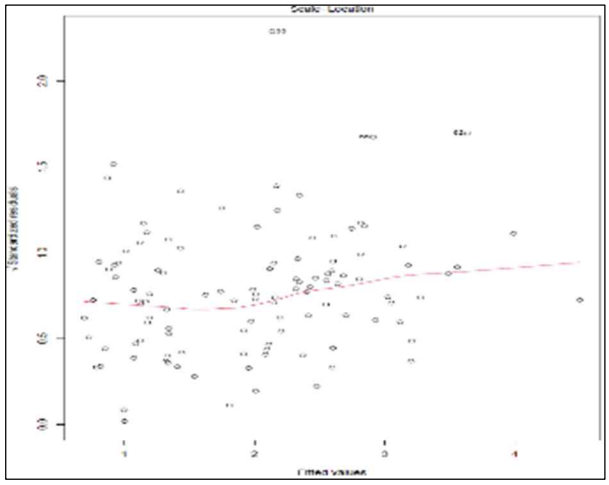


Figure 14. Scale-Location Plot (sample II)

In addition, specifications with the time dummies and interaction terms are also analyzed considering the nature of the dataset (pooled cross-sectional data), which consists of different shipping bank loans over multiple periods. The study's time period (2003~2018) covers both boom and bust periods of the shipping cycle. Time dummies are included to account for common shocks in the boom period (2003~2008) and bust period (2009~2018). Explanatory variables found statistically significant in the regression model with time dummies are interacted to examine whether their effects changed in that period compared to another period in the sample. However, both results of the specifications showed that none of the coefficient estimates are statistically significant due to the small dataset.

4.3 Variable Selection

The theory on the risk structure of interest rates shows that credit risk is one attribute that influences the interest rate of a bond. There are also several existing literatures explaining the relationship between the interest rate and credit risk. Fabbro and Hack (2011) argue that the costs of debt and equity funding and the expected losses on the loans are the most important determinants of banks' lending rates. In business lending, debt funding costs have been the key driver of the increase in lending rates in Australia. Beau et al. (2014) show that the cost of funding can be decomposed into risk-free component, credit risk premium, and liquidity risk premium. The risk premium is influenced by both idiosyncratic as well as macro risk factors. In the shipping finance literature, Grammenos (2010) points out that assessing the probability of credit risk is linked with the pricing of shipping loans. In this study, the response variable, margin which is defined as credit spread over LIBOR, aims to approximate credit risk of shipping bank loan.

A total of 23 explanatory variables consisting of financial and non-financial factors that affect the credit risk of shipping bank loans are selected for the study based on risk criteria used in shipping banks and existing literature including Kavussanos and Tsouknidis (2016), Mitroussi et al. (2016) and Lozinskaia et al. (2017). Four different models are established based on a set of explanatory variables representing loan-specific factors, firm characteristics, financial characteristics, and market risk. M5 model consisting of all 21 explanatory variables is constructed. To address the issue of multicollinearity, variables that exhibit more than 60% of correlation are not used simultaneously in the models.

Table 3 presents the explanatory variables used in the study. Loan-specific variables include: (1) Credit Default Swap (CDS) spread provides insurance against default risk of the reference obligation (bond). Duffie (1999) shows that CDS spreads equal credit spreads under certain

circumstances, and CDS spread is used as a proxy for the bank's funding cost. A monthly average of 5-year CDS spread one month before the loan commitment date is used. A positive sign is expected because CDS spreads increase when the reference bonds become riskier and vice versa. (2) The debt ratio represents the total amount of syndication expressed as a percentage of the total project cost. The syndication amount consists of a loan and guarantee/insurance provided by the syndicated lenders, and the project cost is the total amount required to purchase the vessel(s). The project cost consists of the vessel price, capitalized interest, and legal fees. The debt ratio can also be used as a proxy of asset coverage ratio, measuring asset risk. A negative sign of its coefficients is more likely since the bank typically asks for a higher percentage of equity from the borrower with loans evaluated as a high-risk loan. (3) Debt service coverage ratio (DSCR) is defined as cash flow available for debt service divided by the repayment amount of principal and interest. This ratio is an indicator commonly used by the lenders to assess the annual repayment capability of the borrower. The expected sign is negative since higher DSCR increases the probability of the borrower to repay its loan. (4) The guarantee ratio is the total amount of guarantee and/or insurance over the total amount of syndication. The guarantee/insurance is provided to protect the lenders in the syndication against the credit risk of the borrower. A positive sign of its coefficients is expected because the lenders will ask for a higher amount of guarantee if the loan is considered a higher risk. (5) Charter represented by a dummy variable, shows whether the project being financed has a third-party time-charter contract. A value of 1 will be assigned if the project has a time-charter contract, if not, a value of 0. A positive sign is expected since the time-charter contract would ensure more stable and predictable cash flows, thereby reducing the borrower's credit risk.

Firm-characteristics variables include: (1) Charter policy represented by a dummy variable, measures whether the borrower operates the majority of its fleet on the time-charter contract

(taking the value 1) or on voyage charters (taking the value 0). A positive sign is expected since the borrower with more than 50% of its fleet in time-charter, would be less exposed to the volatile freight risk. (2) The age of the firm is measured as the time period in years until 2018 since the inception of the borrower. Mitroussi et al. (2016) and Kanvussanos and Tsouknidis (2016b) also included the firm's age as one of the variables in their research. The expected sign is negative since older firms would have more experience in the shipping industry, making them less vulnerable to the probability of default. (3) The fleet is defined as the number of vessels either owned or leased operated by the borrower. A negative sign is expected since a borrower with a larger fleet typically has more financial strength and experience, thus reducing the credit risk.

Financial-characteristics variables include: (1) leverage ratio, defined as total debt/total assets, is a primary indicator of the borrower's long-term repayment capacity. A positive sign is expected since a higher leverage ratio increases the credit risk of the borrower. (2) The debt coverage ratio measures the borrower's capacity to service the short and long-term debt based on the profit from its operating activities. Due to the capital intensive nature of the industry and heavy deprecation expenses, Earnings Before Interest Taxes Depreciation and Amortization (EBIDTA) is typically used as a common performance measure to compare results among peers in shipping. Four different types of debt coverage ratios are used in the study: debt coverage ratio1 (current liabilities/EBITDA), debt coverage ratio2 (long-term debt/EBITDA), debt coverage ratio3 (total liabilities/EBITDA) and debt coverage ratio4 (interest expense/EBITDA). A positive sign is expected since the higher the debt coverage ratio indicates a higher debt burden relative to its operating profits, thus increasing the borrower's credit risk. (4) Liquidity ratio is used to examine the ability of the borrower to pay off its short-term debt. Two liquidity ratios are used in the study: liquidity ratio1 (current assets/current

liabilities) and liquidity ratio2 (cash and cash equivalents/Total assets). A negative sign is expected since higher liquidity is an indication of a higher probability of repayment from the borrower. (5) Profit margin ratio, defined as EBITDA/revenue, evaluates the borrower's operating performance as a result of utilizing its assets. A negative sign is expected since the higher the profit margin, the lower the borrower's credit risk.

Market risk variables include: (1) orderbook to fleet ratio measures the percentage of vessels (dwt) on order in the market over the total fleet capacity. It is typically used as an indicator of future changes to global fleet supply. The expected sign is positive since a higher orderbook to fleet ratio relative to the total fleet would more likely result in lower freight rates and lower revenue for the borrower. (2) Newbuilding price index is constructed with annual newbuilding prices of vessels with January 1988 as its basis year. Newbuilding price index reflects current earning and future market expectations and has a high correlation with freight rates. A negative sign is expected since a higher newbuilding price index rate would lead to a higher freight rate and increased income for the shipping companies, thus lowering the borrower's credit risk. (3) MSCI world index, published by Morgan Stanly, is a benchmark index of global stock market prices in 23 developed countries. According to Lozinskaia et al. (2017), there is a high correlation between MSCI index and freight rates, and MSCI index is often used as a forward-looking proxy indicator of freight rates. A negative sign is expected since the high MSCI index indicates a strong global economy and high freight rates, thus reducing the borrower's credit risk. (4) Baltic Dry Index (BDI) is an indicator of broader shipping market conditions. A negative sign is expected since higher BDI indicates a strong freight market and higher income for the borrowers, reducing the borrower's credit risk. (5) ClarkSea index is constructed as a weighted average of earning in the shipping industry and is also widely used as an earnings indicator. A negative sign is expected since a higher ClarkSea index suggests higher revenue

for the borrowers, reducing the borrower's credit risk. (6) Oil price is a key driver of market demand in the shipping industry. A positive sign is expected since a higher oil price would result in a higher level of competition and lower revenue, thus increasing the borrower's credit risk. (7) GDP measures the overall economic condition of a country. A negative sign is expected since a high level of GDP represents a strong economy and improved freight rates, thus reducing the borrower's credit risk.

Table 3. Description of Explanatory Variables

Variable	Description	Expected sign
Loan-specific variables		
CDS spread	Premium paid against default risk of the reference obligation (bond)	+
Debt ratio	Total amount of syndication/total project cost	-
DSCR	Debt service coverage ratio = cash flow available for debt service/repayment amount of principal and interest	-
Guarantee ratio	Total amount of guarantee and/or insurance/ total amount of syndication	+
Charter	A dummy variable taking the value of 1 for third-party time-chartered vessel(s) and 0 for voyage-chartered vessel(s)	+
Firm-characteristics variables		
Age	Time period since the inception of the company	-
Charter policy	A dummy variable taking the value of 1 if the company's main chartering policy is time charter and 0 if the company's main chartering policy is voyage charter	-
Fleet	Number of vessels either owned or leased operated by the company	-
Financial-characteristics variables		
Leverage ratio	Total liabilities/Total assets	+
Debt coverage ratio1	Current liabilities/EBITDA	+
Debt coverage ratio2	Long-term debt/EBITDA	+
Debt coverage ratio3	Total liabilities/EBITDA	+
Debt coverage ratio4	Interest expense/EBTIDA	+
Liquidity ratio1	Current assets/Current liabilities	-
Liquidity ratio2	Cash and cash equivalents/Total Assets	-
Profit margin ratio	EBITDA/ revenue	-
Market risk variables		
Orderbook to fleet ratio	Global orderbook (dwt)/Total fleet (dwt)	+
Newbuilding price index	An index of annual newbuilding prices (1988=100)	-
MSCI index	An index of global stock market prices in 23 developed countries	-
BDI	Baltic Dry Index	-
ClarkSea index	An index of weighted average of earning in shipping	-
Oil price	Brent oil price	+
GDP	Gross Domestic Product	-

Tables 4 and 5 present the pair-wise linear correlations among all explanatory variables for sample I and II. In the correlation matrix of sample I, nine pairs are found highly correlated in excess of 0.60: leverage ratio and debt coverage ratio1 (0.72), leverage ratio and debt coverage ratio3 (0.78), debt coverage ratio1 and debt coverage ratio3 (0.88), orderbook to fleet ratio and newbuilding index (0.64), newbuilding index and BDI (0.74), newbuilding index and ClarkSea index (0.67), newbuilding index and GDP (0.63), BDI and ClarkSea index (0.92), ClarkSea index and GDP (0.68). In the correlation matrix of sample II, three pairs are found highly correlated in excess of 0.60: newbuilding index and BDI (0.75), newbuilding index and ClarkSea index (0.69), BDI and ClarkSea index (0.91). To avoid multicollinearity, pairs of variables that exhibit more than 0.60 of correlation in both sample I and sample II are not included simultaneously in the models.

Table 4. Correlation Matrix (sample I)

	Margin	CDS spread	Debt ratio	Guarantee ratio	DSCR	Charter	Charter policy	Age	Fleet	Leverage ratio	Debt coverage ratio1	Debt coverage ratio2	Debt coverage ratio3	Debt coverage ratio4	Liquidity ratio1	Liquidity ratio2	Profit margin ratio	Order-book to fleet ratio	New-building price index	MSCI index	BDI	Clark-Sea index	Oil price	GDP
Margin	1.00																							
CDS spread	0.57	1.00																						
Debt ratio	-0.29	-0.17	1.00																					
Guarantee ratio	0.35	0.01	-0.13	1.00																				
DSCR	-0.02	-0.11	-0.13	-0.02	1.00																			
Charter	0.02	0.08	0.24	-0.03	-0.39	1.00																		
Charter policy	-0.20	-0.34	-0.14	0.11	0.36	-0.72	1.00																	
Age	-0.20	-0.10	-0.20	-0.26	-0.19	-0.30	-0.03	1.00																
Fleet	-0.13	0.01	-0.07	-0.10	-0.16	-0.09	0.15	0.46	1.00															
Leverage ratio	0.03	0.14	0.18	-0.08	-0.24	0.50	-0.31	-0.04	-0.02	1.00														
Debt coverage ratio1	0.14	-0.01	0.02	0.18	-0.18	0.35	-0.25	-0.12	0.02	**0.72**	1.00													
Debt coverage ratio2	0.13	0.17	0.04	0.02	-0.12	0.06	-0.09	-0.18	-0.10	0.08	-0.01	1.00												
Debt coverage ratio3	0.15	0.01	-0.02	0.08	-0.09	0.21	-0.15	-0.07	-0.05	**0.78**	**0.88**	-0.06	1.00											
Debt coverage ratio4	0.07	0.07	-0.01	0.07	-0.18	0.32	-0.22	-0.14	-0.02	0.41	0.43	0.57	0.30	1.00										
Liquidity ratio1	0.10	-0.06	-0.11	0.38	0.04	-0.07	0.13	-0.19	-0.14	-0.24	-0.08	-0.12	-0.03	-0.15	1.00									
Liquidity ratio2	-0.04	-0.10	-0.02	0.08	0.13	-0.31	0.26	0.07	-0.01	-0.22	-0.03	-0.09	0.00	-0.21	0.49	1.00								
Profit margin ratio	-0.26	0.00	0.13	-0.25	-0.10	0.02	-0.09	0.11	0.09	0.09	0.04	0.31	0.02	0.14	-0.45	-0.19	1.00							
Orderbook to fleet ratio	-0.17	0.26	-0.17	-0.26	-0.10	-0.21	0.11	0.20	0.23	-0.14	-0.13	-0.18	-0.08	-0.26	-0.06	0.21	0.07	1.00						
Newbuilding price index	-0.67	-0.44	0.08	-0.30	-0.08	-0.16	0.24	0.19	0.06	-0.12	-0.12	-0.22	-0.07	-0.22	0.00	0.29	0.06	**0.64**	1.00					
MSCI index	0.25	-0.12	-0.23	0.58	0.09	-0.01	0.07	-0.21	0.06	-0.12	0.21	-0.06	0.09	0.15	0.18	-0.08	-0.19	-0.16	-0.20	1.00				
BDI	-0.61	-0.23	0.17	-0.39	-0.19	0.09	0.04	0.25	0.00	0.05	-0.12	-0.11	-0.04	-0.13	-0.11	0.13	0.14	0.48	**0.74**	-0.41	1.00			
ClarkSea index	-0.66	-0.35	0.26	-0.41	-0.18	0.05	0.06	0.28	0.01	0.07	-0.11	-0.09	-0.05	-0.11	-0.11	0.09	0.16	0.32	**0.67**	-0.48	**0.92**	1.00		
Oil price	0.48	0.40	-0.38	0.16	0.00	-0.04	-0.08	-0.10	0.08	-0.08	0.14	-0.08	0.17	0.00	0.12	0.14	-0.25	0.40	0.07	0.35	-0.20	-0.38	1.00	
GDP	-0.65	-0.50	0.23	-0.50	-0.11	-0.08	0.20	0.27	0.07	0.01	-0.18	-0.07	-0.10	-0.13	-0.09	0.14	0.16	0.15	**0.63**	-0.58	0.60	**0.68**	-0.40	1.00

Table 5. Correlation Matrix (sample II)

	Margin	CDS spread	Debt ratio	Guarantee ratio	DSCR	Charter	Charter policy	Age	Fleet	Leverage ratio	Debt coverage ratio1	Debt coverage ratio2	Debt coverage ratio3	Debt coverage ratio4	Liquidity ratio1	Liquidity ratio2	Profit margin ratio	Order-book to fleet ratio	New-building index	MSCI index	BDI	Clark-Sea index	Oil price	GDP
Margin	1.00																							
CDS spread	**0.62**	1.00																						
Debt ratio	-0.18	-0.13	1.00																					
Guarantee ratio	0.37	0.07	-0.04	1.00																				
DSCR	0.06	0.02	-0.05	0.06	1.00																			
Charter	0.20	0.12	0.21	0.14	-0.19	1.00																		
Charter policy	-0.36	-0.33	-0.17	-0.06	0.22	-0.73	1.00																	
Age	-0.24	-0.15	-0.18	-0.23	-0.19	-0.25	0.07	1.00																
Fleet	-0.18	-0.04	-0.06	-0.11	-0.13	-0.15	0.19	0.46	1.00															
Leverage ratio	-0.05	-0.04	0.27	-0.12	-0.27	0.51	-0.32	-0.01	0.02	1.00														
Debt coverage ratio1	0.05	0.01	0.02	0.14	-0.19	0.32	-0.26	-0.14	0.10	0.30	1.00													
Debt coverage ratio2	0.23	0.25	0.01	0.12	-0.06	0.30	-0.29	-0.18	-0.13	0.18	0.00	1.00												
Debt coverage ratio3	-0.08	-0.07	0.03	0.02	-0.20	0.22	-0.17	-0.08	0.03	0.31	0.55	0.42	1.00											
Debt coverage ratio4	0.05	0.05	-0.02	0.07	-0.12	0.35	-0.28	-0.13	-0.02	0.34	0.47	0.48	0.51	1.00										
Liquidity ratio1	0.03	-0.07	-0.09	0.29	0.01	-0.10	0.14	-0.19	-0.13	-0.35	-0.1	-0.13	-0.10	-0.15	1.00									
Liquidity ratio2	-0.08	-0.10	-0.04	-0.01	0.00	-0.27	0.23	0.05	0.00	-0.34	-0.04	-0.16	-0.06	-0.15	0.43	1.00								
Profit margin ratio	-0.19	-0.09	0.15	-0.07	0.05	0.17	-0.31	-0.39	-0.25	0.18	-0.13	0.00	0.00	-0.05	-0.06	-0.26	1.00							
Orderbook to fleet ratio	-0.05	0.45	-0.16	-0.20	-0.20	-0.08	0.07	0.14	0.15	-0.11	-0.16	0.07	-0.22	-0.18	-0.07	0.14	-0.09	1.00						
Newbuilding index	-0.64	-0.34	0.03	-0.27	-0.19	-0.15	0.34	0.24	0.07	-0.11	-0.15	-0.18	-0.16	-0.18	0.01	0.26	0.01	0.58	1.00					
MSCI index	0.19	-0.10	-0.16	0.54	0.14	-0.04	0.07	-0.18	0.05	-0.24	0.24	-0.11	0.06	0.12	0.16	-0.06	-0.11	-0.26	-0.20	1.00				
BDI	-0.57	-0.18	0.12	-0.35	-0.23	-0.03	0.15	0.24	0.03	0.10	-0.16	-0.09	-0.10	-0.11	-0.08	0.13	-0.03	0.49	**0.75**	-0.39	1.00			
ClarkSea index	-0.67	-0.36	0.19	-0.40	-0.24	-0.10	0.21	0.29	0.05	0.12	-0.13	-0.13	-0.04	-0.11	-0.07	0.12	0.00	0.29	**0.69**	-0.43	**0.91**	1.00		
Oil price	0.51	0.50	-0.29	0.26	0.06	0.14	-0.23	-0.11	0.02	-0.24	0.09	0.08	-0.02	0.06	0.05	0.11	-0.11	0.32	0.01	0.31	-0.23	-0.41	1.00	
GDP	-0.64	-0.54	0.17	-0.43	-0.16	-0.08	0.29	0.24	0.08	0.03	-0.13	-0.07	0.14	-0.08	-0.03	0.12	0.06	-0.01	0.54	-0.42	0.47	0.60	-0.36	1.00

CHAPTER 5 RESULTS

Equation (1) is estimated for two different samples: a sample consisting of commercial vessels (sample I) and a sample consisting of commercial vessels and offshore facilities (sample II). As shown in table 6, the estimates of the regression are first classified into four different models, namely M1(loan-specific variables), M2(firm-characteristics variables), M3(financial-characteristics variables), and M4(market risk variables). It should be noted that M1~M4 are estimated only to examine the explanatory power of different models. In M5 model, all explanatory variables used in M1~M4 models are included to estimate the statistically significant variables using stepwise method.

To avoid multicollinearity, explanatory variables that exhibit more than 60% of correlation in both sample I and sample II are excluded from the models. The mean variance inflation factor (VIF) computed for each model shows no serious presence of multicollinearity.

Table 6. Regression Models

Model	Regression equation
M1 (Loan-specific)	Y = CDS spread + Debt ratio + DSCR + Guarantee ratio + Charter
M2 (Firm-characteristics)	Y = Age + Charter policy + Fleet
M3 (Financial-characteristics)	Y = Leverage ratio + Debt coverage ratio1 + Debt coverage ratio2 + Debt coverage ratio3 + Debt coverage ratio4 + Liquidity ratio1 + Liquidity ratio2 + Profit margin ratio
M4 (Market risk)	Y = Orderbook to fleet ratio + MSCI index + ClarkSea index + Oil price + GDP
M5	Y = CDS spread + Debt ratio + DSCR + Guarantee ratio + Charter + Age + Charter policy + Fleet + Leverage ratio + Debt coverage ratio1 + Debt coverage ratio2 +Debt coverage ratio3 + Debt coverage ratio4 + Liquidity ratio1 + Liquidity ratio2 + Profit margin ratio + Orderbook to fleet ratio + MSCI index + ClarkSea index + Oil price + GDP

5.1 Sample I

Table 7 presents the results of the regression analysis of sample I. In M1 model, five loan-specific variables are included. M1 exhibits the second highest adjusted R^2 (45.04%) among M1~M4 models. CDS spread and guarantee ratio are found statistically significant in explaining the credit risk. The M2 model contains three variables on firm-characteristics of the borrower. Adjusted R^2 is 3.68%. There is no variable found statistically significant in this model. The M3 model considers eight variables on financial-characteristics of the borrower. Adjusted R^2 is 2.06%. Profit margin ratio is the only variable found statistically significant variable in this model. The M4 model consists of five variables on market risk and has the highest adjusted R^2 (60.30%) among M1~M4 models. MSCI index, oil price, and GDP are variables found statistically significant in M4 model.

Next, the M5 model examines all 21 variables using the stepwise method. It has the highest adjusted R^2 (72.00%) among all models examined (M1~M5). A total of six variables are found significant, namely two loan-specific variables (CDS spread and DSCR), one firm-characteristics variable (fleet), and three market risk variables (orderbook to fleet ratio, ClarkSea index, oil price).

All statistically significant explanatory variables have the correct a-priori signs except for orderbook to fleet ratio. It was expected that orderbook to fleet ratio is positively associated with the borrower's credit risk. However, the results indicate an indirect relationship. This could be explained by the vessel profile of the sample which is different from the global fleet composition. According to Clarksons research, the largest share of total cargo fleet belonged to bulk carriers, accounting for 44.6% in 2018. In the sample used in the study, however bulk carrier accounts for less than 1% while containership and gas carrier account for 63.5%. Therefore, the increase in orderbook to fleet ratio would influence these non-bulk carrier sub-

sectors more positively than negatively as they account for less share of the total fleet composition.

Standardized coefficients of M5 are reported in table 7 as follows: for CDS spread it is 0.4728, for DSCR it is -0.1890, for fleet it is -0.1858, for orderbook to fleet ratio it is -0.3094, for ClarkSea index it is -0.3586, and for oil price it is 0.2364. Based on the magnitude of the standardized coefficients, it can be argued that CDS spread is the most important factor in determining the borrower's credit risk. ClarkSea index and orderbook to fleet ratio are second and third factors with most impact. Meanwhile, fleet has the lowest impact on the borrower's credit risk among six variables found statistically significant in M5.

Table 7. Regression Results (sample I)

	M1	M2	M3	M4	M5	M5 Standardized Coefficients
Loan-specific variables						
Constant	1.8277* (2.19)	2.1465*** (12.78)	2.1505*** (6.04)	5.2316*** (6.57)	3.2665*** (5.39)	
CDS spread	0.0158*** (5.32)	-	-	-	0.0134*** (6.16)	0.4728
Debt ratio	-1.3385 (-1.52)	-	-	-		
DSCR	-0.1656 (-0.50)	-	-	-	-0.8417** (-3.00)	-0.1890
Guarantee ratio	1.3006*** (5.05)	-	-	-		
Charter	0.0786 (0.42)	-	-	-	-	
Firm-characteristics variables						
Age	-	-0.0042 (-1.49)	-	-	-	
Charter policy	-	-0.2956 (-1.55)	-	-	-	
Fleet	-	-0.00006 (-0.11)	-	-	-0.0009* (-2.29)	-0.1858
Financial-characteristics variables						
Leverage ratio	-	-	-0.2163 (-0.37)	-	-	
Debt coverage ratio1	-	-	0.0031 (0.06)	-	-	
Debt coverage ratio2	-	-	0.0203 (0.37)	-	-	
Debt coverage ratio3	-	-	0.0005 (0.01)	-	-	
Debt coverage ratio4	-	-	-0.0930 (-0.17)	-	-0.2946 (-1.33)	
Liquidity ratio1	-	-	0.0117 (0.97)	--	-	
Liquidity ratio2	-	-	-1.4177 (-1.65)	-		
Profit margin ratio	-	-	-0.5160* (-2.05)	-	-0.4946 (-1.55)	
Market risk variables						
Orderbook to fleet ratio				-2,2242 (-1.22)	-3.0890* (-2.37)	-0.3094
MSCI index				-0.0009*** (-4.64)		
ClarkSea index				-0.0002 (-1.47)	-0.00002** (-3.25)	-0.3586
Oil price	-	-	-	0.0131*** (3.87)	0.0078* (2.15)	0.2364
GDP				-0.4443* (-2.61)		
Adjusted R^2	45.04%	3.68%	2.06%	60.30%	72.00%	
F-statistics	16.08	2.17	1.24	28.95	30.57	
Mean VIF	1.08	1.20	2.89	1.99	1.51	

*: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

5.2 Sample II

Table 8 presents the results of the regression analysis of sample II. In M1 model, five loan-specific variables are included. CDS spread and guarantee ratio are statistically significant in explaining the credit risk and they both have the correct a-prior expected signs. M1 exhibits the second highest adjusted R^2 (49.24%) among M1~M4 models. The M2 model contains three variables on the firm-characteristics of the borrower. Adjusted R^2 is 11.09%. Age and charter policy are found statistically significant in this model. The M3 model considers eight variables on financial-characteristics of the borrower. Adjusted R^2 is 12.24%. Debt coverage ratio2, debt coverage ratio3 and profit margin ratio are found statistically significant in this model. The M4 model consists of five variables on market risk with the highest adjusted R^2 (61.95%) among M1~M4 models. MSCI index, ClarkSea index, oil price and GDP are found statistically significant in this model.

Next, M5 model examines all 21 variables using the stepwise method. M5 model has the highest adjusted R^2 (70.93%) among all models (M1~M5). A total of eight variables are found significant, namely two loan-specific variables (CDS spread, DSCR), three financial-characteristics variables (debt coverage ratio2, debt coverage ratio4, profit margin ratio) and three market risk variables (orderbook to fleet ratio, ClarkSea index, oil price).

All statistically significant explanatory variables have correct a-priori signs except for debt coverage ratio4 and orderbook to fleet ratio. First, it was expected that debt coverage ratio4 (interest expense/EBITDA) is positively associated with the borrower's credit risk. However, the results indicate an indirect relationship. This could be explained by the changed shipping finance landscape over the last decade. In particular the declining share of bank loans resulted in only the top tier shipping companies being able to finance their vessel(s) with bank loans. Accordingly, the capacity to secure a shipping loan from banks is an indication that the shipping

company has relatively lower credit risk and has passed the rigorous credit analysis of banks.

Second, it was expected that orderbook to fleet ratio is positively associated with the credit risk of the borrower. However, the results indicate an indirect relationship. This could be explained by the vessel profile of the sample which is different from the global fleet composition. According to Clarkson research, the largest share of total cargo fleet belongs to bulk carriers, accounting for 44.6% in 2018. In the sample used in the study, however bulk carrier accounts for less than 1% while containership and gas carrier accounting for 63.5%. Therefore, the increase in orderbook to fleet ratio would influence these non-bulk carrier sub-sectors more positively than negatively as they account for less share of the total fleet composition.

Standardized coefficients of model M5 are reported in table 8 as follows: for the CDS spread it is 0.4315, for DSCR it is -0.1512, for debt coverage ratio2 it is 0.1489, for debt coverage ratio4 it is -0.1176, for profit margin ratio it is -0.0895, for orderbook to fleet ratio it is -0.2925, for ClarkSea index it is -0.2723 and for oil price it is 0.2194. Based on the magnitude of the standardized coefficients, it can be argued that CDS spread is the most important factor in determining the credit risk of the borrower. Orderbook to fleet ratio comes next followed by ClarkSea index. Meanwhile, profit margin ratio and debt coverage ratio4 have the lowest impact on the borrower's credit risk.

Table 8. Regression Results (sample II)

	M1	M2	M3	M4	M5	M5 Standardized Coefficients
Loan-specific variables						
Constant	1.4923* (2.30)	2.4333*** (16.07)	1.8614*** (8.15)	2.1187*** (6.25)	3.5105*** (5.38)	
CDS spread	0.0141*** (6.08)	-	-	-	0.0105*** (3.47)	0.4315
Debt ratio	-1.1717 (-1.59)	-	-	-	-	
DSCR	0.1038 (0.30)	-	-	-	-0.7287** (-2.73)	-0.1512
Guarantee ratio	1.2601*** (4.94)	-	-	-	-	
Charter	0.1896 (1.26)	-	-	-	-	
Firm-characteristics variables						
Age	-	-0.0047^{+} (-1.94)	-	-	-	
Charter policy	-	-0.5093** (-2.93)	-	-	-	
Fleet	-	-0.0002 (-0.48)	-	-	-0.0005 (-1.45)	
Financial-characteristics variables						
Leverage ratio	-	-	-0.1203 (-0.48)	-	-	
Debt coverage ratio1	-	-	0.0314 (1.20)	-	-	
Debt coverage ratio2	-	-	0.0682*** (3.45)	-	0.0254^{+} (1.94)	0.1489
Debt coverage ratio3	-	-	-0.0122* (-2.01)	-	-0.0048 (-1.30)	
Debt coverage ratio4	-	-	-0.3903 (-0.65)	-	-0.3986* (-2.02)	-0.1176
Liquidity ratio1	-	-	0.0084 (0.52)	-	-	
Liquidity ratio2	-	-	-0.6795 (-0.77)	-	-	
Profit margin ratio	-	-	-0.0826*** (-5.45)	-	-0.0352^{+} (-1.97)	-0.0895
Market risk variables						
Orderbook to fleet ratio	-	-	-	-1.3796 (-1.00)	-2.8836** (-2.75)	-0.2925
MSCI index	-	-	-	-0.0008*** (-4.24)	-	
ClarkSea index	-	-	-	-0.00003* (-2.41)	-0.00002* (-2.24)	-0.2723
Oil price	-	-	-	0.0115*** (4.56)	0.0075** (2.96)	0.2194
GDP				-0.3965** (-3.04)	-0.1269 (-1.04)	
Adjusted R^2	49.24%	11.09%	12.24%	61.95%	70.93%	
F-statistics	22.54	5.61	2.93	37.15	25.62	
Mean VIF	1.05	1.19	1.52	1.82	1.76	

$^{+}$: $p < 0.1$, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$

5.3 Discussion

The results of the regression analysis (M5) on two different samples suggest several interesting points for discussion. First, market risk is the most important driver of credit risk. This finding is in agreement with previous studies on credit risk of shipping finance and provides new evidence that market risk is an equally important risk driver in offshore facilities. Failure of market risk management in shipping is more often than not the key factor behind credit deterioration of credit risk of shipping companies. Kavussanos and Tsouknidis (2016) suggest that accurate assessment of market risk factors requires selecting the risk indicator that represents the unique characteristics of the shipping industry. The study further contributes to the findings of existing literature by indicating that the composition of vessel profile affects the market risk variables in different ways. Orderbook to fleet ratio, ClarkSea index and oil price are all found statistically significant in both sample I and sample II. However, ClarkSea index is found relatively more important in sample I while orderbook to fleet ratio is found relatively more important in sample II. This could be explained by differences in the type of employment between the two sub-sectors. Commercial vessels react more sensitively to the freight rate fluctuations than offshore facilities which are mostly financed based on long-term charter agreements.

Second, DSCR is found statistically significant in both samples. DSCR is a variable that represents the cash flow risk and, together with market risk, is a fundamental variable in assessing the borrower's credit risk in shipping loans.

Third, results indicate that the borrower's financial capacity is considered an important element in assessing credit risk of shipping loans to the offshore sector. None of the financial variables are found statistically significant in sample I while debt coverage ratio2, debt coverage ratio4 and profit margin ratio are found statistically significant at 5% and 10% level

of significance. This can be explained by the specific characteristics of the way offshore facilities are employed and financed[22]. Unlike commercial vessels, offshore facilities are mostly financed with medium and long-term charter contracts, which serve as a key source of loan repayment in shipping loans. This means that the borrower's corporate risk is partly transformed into the corporate risk of a charterer in offshore financing. To ensure stable cash flow, the risk analysis should thus shift to thoroughly analyzing the charterer's financial strength as well as the main security protection clauses of charterparty. This also suggests that risk analysis of sample II is more focused on corporate finance than that of sample I.

With respect to the charterparty, lenders should recognize that a high level of counterparty credit risk exists in offshore financing. That is, lenders are not provided the same degree of legal rights to step-in and remedy problems in situations such as an event of default or charter termination. This is very different from project finance, where lenders have direct rights to prevent or mitigate the potential termination of key project documents such as offtake agreements in the event of default. Even with step-in rights, offshore projects are extremely difficult to replace owner or operator willing to accept the financial obligations of the existing project documents. For these reasons, lenders should not be misled by the notion that a long-term charter of an offshore facility is a guarantee of loan repayment. More attention is required in assessing the charterer's financial capacity and what the charter agreement entails in terms of legal protection for lenders. It is a reminder to lenders that financial strength of the borrower and the charterer is what ultimately matters and serves as the last line of defense in credit risk management.

[22] Norton Rose Fulbright, 2018. *A clash of two worlds: letters of quiet enjoyment in offshore project financings*, October, 2018.

CHAPTER 6 CONCLUSION

This study examines the major determinants of credit risk of shipping bank loans of an international shipping portfolio for 2003~2018. The dataset is analyzed with two samples to compare the factors affecting the credit risk of portfolios containing only commercial vessels and a more comprehensive portfolio containing offshore facilities. The results suggest that there are common factors and differences between the two samples regarding variables that affect credit risk.

First, market risk is the single most important factor for estimating credit risk in shipping bank loans. In this study, market risk variables are found statistically significant in both commercial vessels and offshore facilities with orderbook to fleet ratio, ClarkSea index, and oil price found significant in sample I and sample II.

Second, cash flow risk represented by DSCR is an equally important element in credit risk assessment of shipping loans.

Third, risks analysis of loans to the offshore sector require more attention on the borrowers' financial capacity. This is the most notable difference between the results of commercial vessels and offshore facilities. This finding supports the recent experience of banks that financed offshore transactions in which specific legal risks of charterparty translated into counterparty credit risk for banks in market downturn.

In conclusion, the study's key finding is that specific characteristics of shipping bank loans require a customized risk analysis. Market risk is important in credit risk analysis of loans to commercial vessels and offshore facilities. At the same time, the borrower's financial capacity should be analyzed more in detail when financing offshore facilities.

The limitations of the study are as follows. First, a limited number of available datasets constrains a wider selection of methodology and generalization of the study results. Increased

data in both default and non-default shipping loans would allow future research to conduct a more diverse and rigorous research, further providing important implications in evaluating credit risk of shipping bank loans. Second, market risk variables that reflect the vessel composition of the dataset would help further improve the validity of the findings. Third, findings of the study depend critically on how the characteristics of the dataset are defined and what type of methodology is used. In this study, OLS regression is employed and additional analysis with time dummies and interactions terms were used given time-series dimension of dataset. However, such additional specifications did not yield meaningful results due to lack of data. With more available data in shipping bank loans, it is expected that more advanced methodology such as panel data regression analysis could be utilized in analyzing the credit risk of shipping bank loans in future research.

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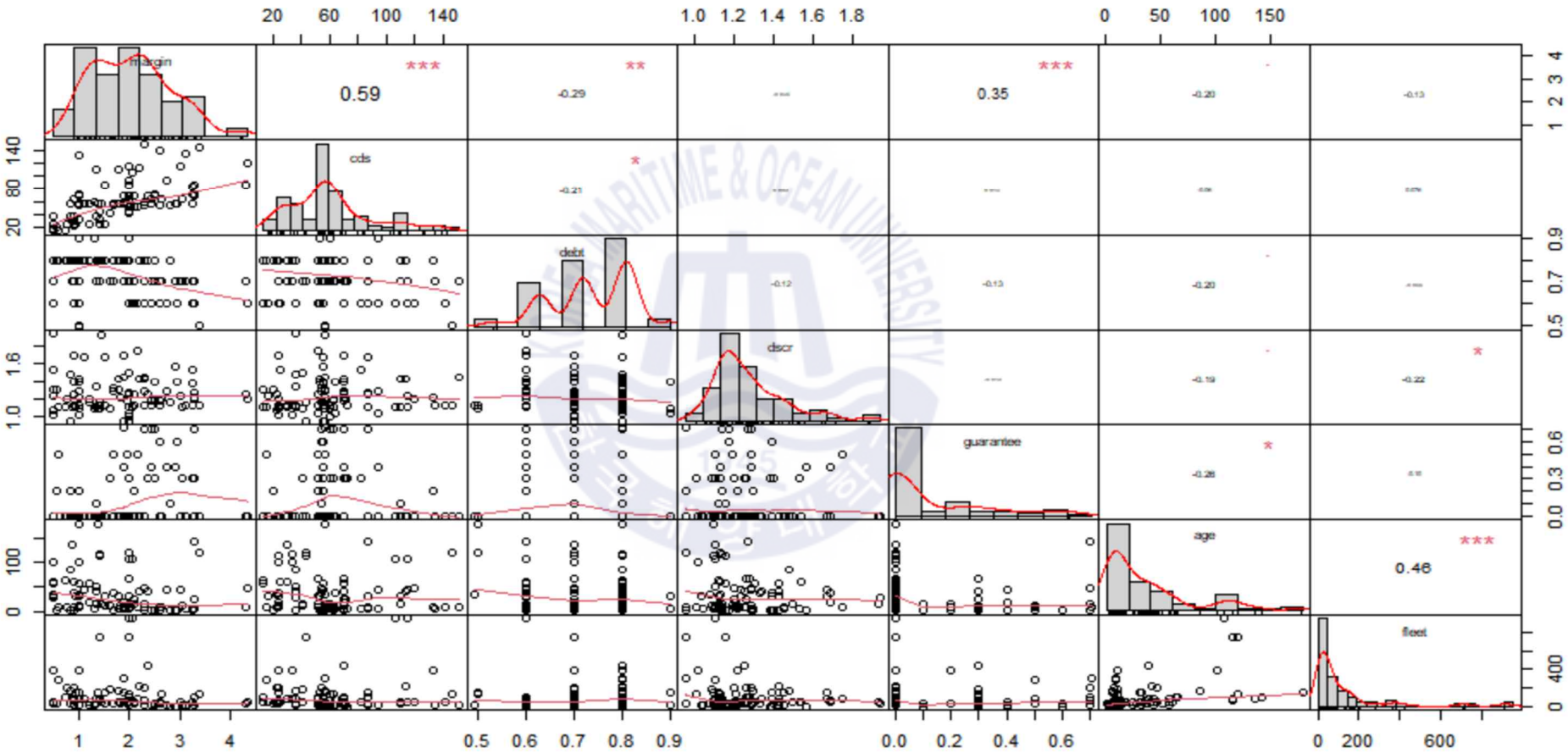
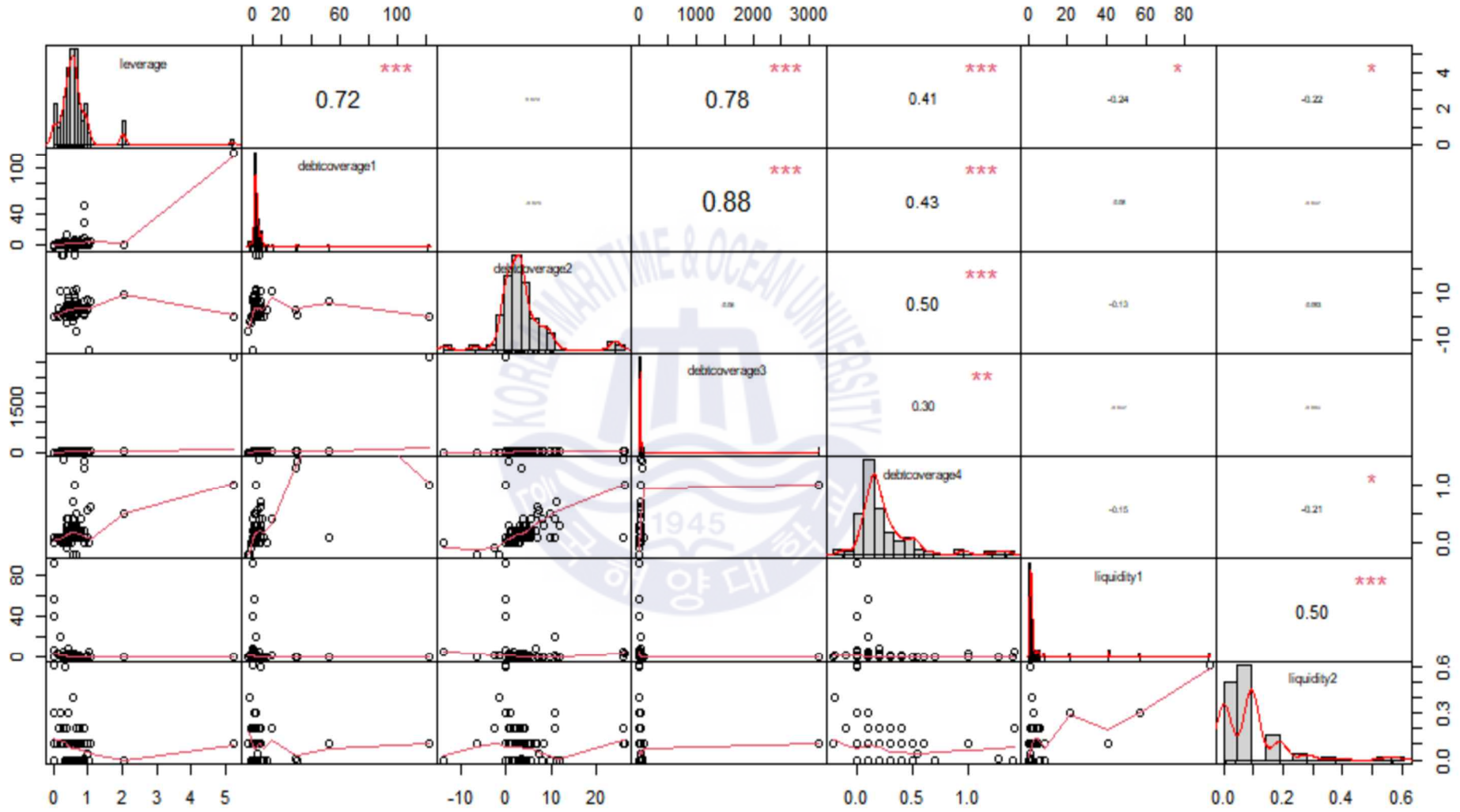
Appendix I

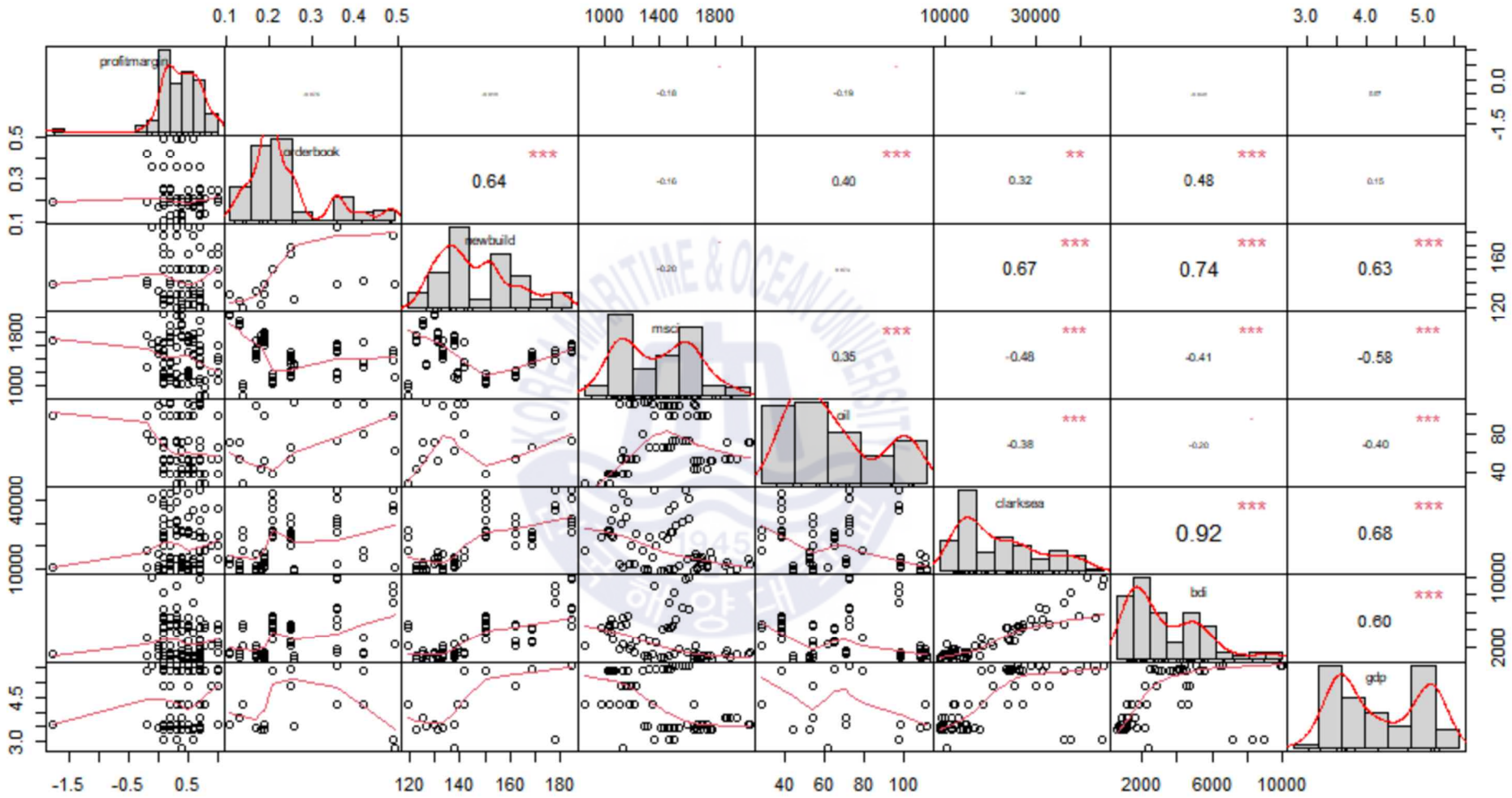
1. Correlation matrix with p-values (sample I)



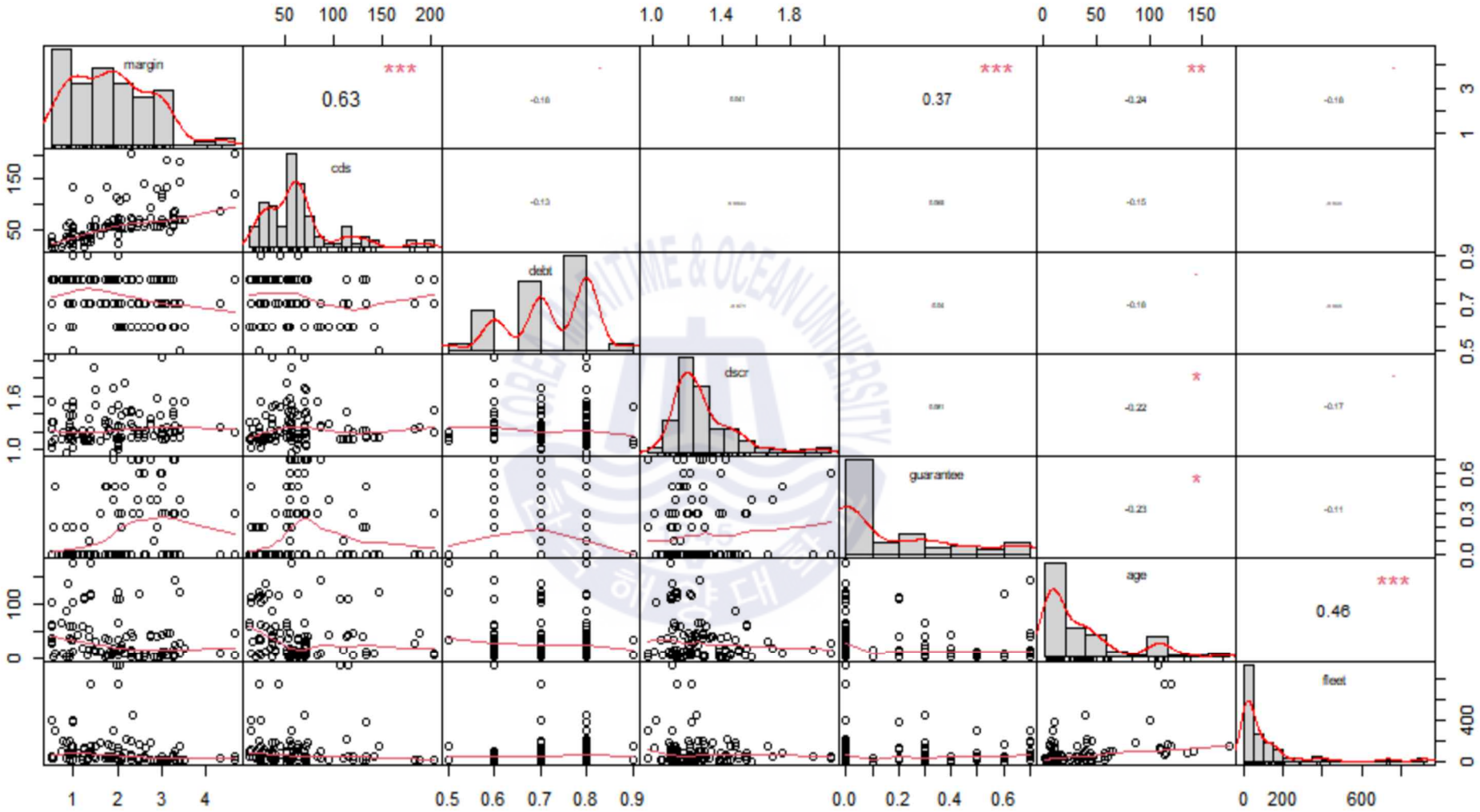
1. **Correlation matrix with p-values (sample I)**



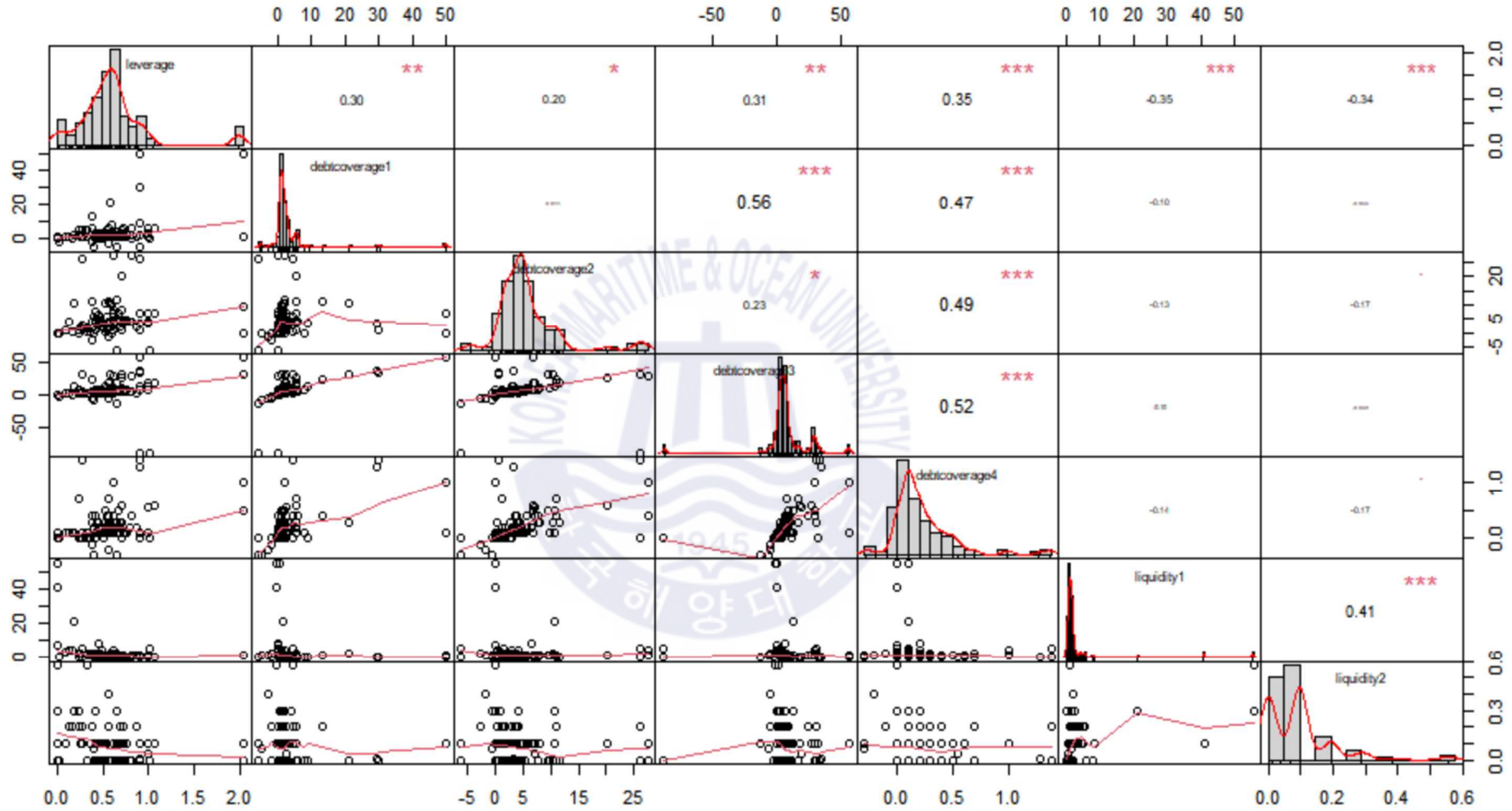
1. Correlation matrix with p-values (sample I)



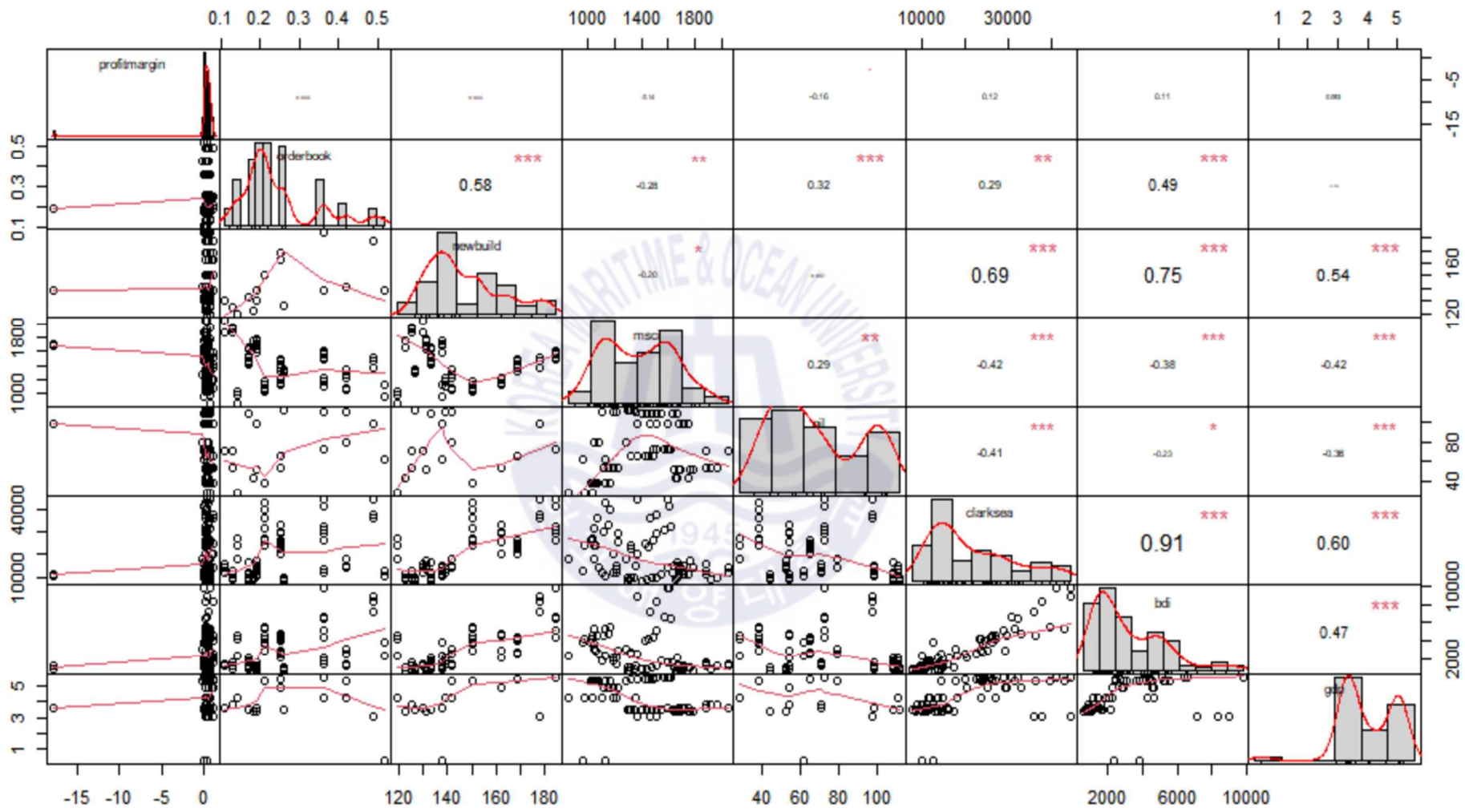
2. Correlation matrix with p-values (sample II)



2. Correlation matrix with p-values (sample II)



3. Correlation matrix with p-values (sample II)



Appendix II

Author(s)	Sample	Methodology	Explanatory Variables	Main Results
Grammenos et al. (2008)	50 high yield bonds (1992~2004)	Logistic regression	Issue specific variables (4) Financial variables (13) Industry specific variables (2)	Financial and industry specific variables are both important. - Financial variable: liquidity ratio, profitability ratio, debt ratio, amount raised over total assets - Industry specific variable: returns of shipping index
Dimitras et al. (2002)	17 shipping loans (1999~2001)	UTADIS	Financial variables (11) Non-financial variables (61)	Non-financial variables are most important. - Ownership & management, credit history, group/fleet characteristics
Gavalas and Syriopoulos (2014)	72 shipping loans from 12 Greek banks	UTADIS	Financial variables (7) Non-financial variables (17)	Financial and non-financial variables are both important. - Financial variable: financial/leverage indicators - Non-financial variable: manager valuation
Kavussanos and Tsouknidis (2014)	54 shipping bonds issued by 20 shipping companies (2003~2010)	Regression	Bond-specific factors (4) Issuer-specific factors (2) Industry-specific factors (3) Macroeconomic factors (4) Interest rates (4) Fama and French factors (3)	Financial and non-financial variables are both important. - Financial variable: liquidity of the bond issue, credit rating of the bond issue - Non-financial variable: stock market's volatility, bond market's cyclicality, freight earnings

Author(s)	Sample	Methodology	Explanatory Variables	Main Results
Kavussanos and Tsouknidis (2016)	128 shipping loans from a Greek bank (1997~2011)	Logistic Regression	Loan-specific variables (6) Firm specific variables (3) Financial specific variables (8) Industry-specific and macroeconomic variables (6)	Non-financial variables are most important. - Freight rate spread/inactive fleet: current and expected future condition of the shipping market - Choice of chartering policy: risk appetite of borrowers - Arrangement fee: other risk factors including relationship banking effect
Mitroussi et al. (2016)	30 dry bulk shipping loans from Greek banks (2005~2009)	Logistic Regression/ Regression	Financial variables (8) Non-financial variables (10)	Financial and non-financial variables are both important. - Financial variables: loan amount, minimum value clause, balloon/loan ratio, fleet leverage, percentage of finance - Non-financial variables: shipowner's experience, freight risk, market sentiment
Lozinskaia et al. (2017)	192 shipping companies in 36 countries	Logistic Regression	Financial variables (9) Non-financial variables (1) Macroeconomic variables (8)	Financial and non-financial variables are both important. - Financial variables: value of the vessel (Tobin Q), value of total assets - Non-financial variables: GDP