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An Analysis of Intraday Liquidity Patterns in the Dry Bulk FFA Market

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Abstract

This thesis investigates different liquidity measures in the dry bulk FFA market by analyzing intraday data of quarterly FFA contracts obtained from Braemar Atlantic Securities Limited. Through intraday data, we conduct analysis previously not accessible on FFA contracts. Due to the lack of previous research on the subject, this paper applies theory and literature from analysis with intraday data in stock markets. In addition, the paper uses theory and literature from previous research on the shipping market. We perform Ordinary Least Squared regressions on liquidity measures such as bid-ask spread, volatility, and volume, in addition to providing illustrations of possible patterns through average statistics in figures.

We discover unexpected patterns throughout the day in regard to bid-ask spreads compared to stock markets. Bid-ask spreads follow a downward trend throughout the day for Capesize and Panamax contracts, while Supramax has some indication of bettering bid-ask spreads in later trading hours. The investigation of volatility provides evidence of contracts with longer time to expiration having less volatility than those with shorter maturities. Furthermore, volume has suggestions of fewer transactions at opening and closing compared to the rest of the day. In this paper, we try to find connections between information asymmetry and the different liquidity measures, using time-dummies at the publication of relevant indices. However, the findings are ambiguous, and we cannot justify the interpretations. However, there is a suggestion of bettering BAS values as information flows to the market.

We believe that conducting such an analysis can benefit hedgers, brokers, clearing houses, investors, and other participants in the dry bulk shipping market, as liquidity in many ways is connected to transaction costs and risk management. Followingly, identifying liquidity patterns in the FFA market would be of benefit to market participants. We hope that our thesis will be of inspiration to future studies.

Preface

This thesis has been written as a concluding part of our Master of Science in Economics and Business Administration at the Norwegian School of Economics.

The main reason behind the choice of topic is our urge to get a deeper knowledge of the financial aspects in an industry which serves as an important factor to the global economy. Furthermore, our shared interest in financial markets and the unique nature of the accessible dataset made the topic of liquidity in the shipping derivates market even more interesting. The process of conducting the study proved to be a cognitive challenge and expanded our understanding of shipping and financial markets. Moreover, throughout the process, we gathered experience and insights likely to be of benefit to our future careers.

We would like to thank our supervisor, Roar Ådland, for providing constructive and insightful feedback as well as advice throughout the process. Furthermore, his availability and quick replies were invaluable and of great benefit to our thesis.

And Lastly, we would like to express our gratitude towards Chase Bennett from Zuma Labs for setting aside time for us, even in busy periods, and for providing us with data and information of high quality.

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1. Introduction

Risk management is important in industries riddled with cyclicalities in its rates and prices, such as the shipping industry (Kavussanos & Visvikis, 2006). Followingly, assessing markets with hedging purposes, such as the shipping derivatives market, could prove beneficial to market participants. In regard to these markets, liquidity is a vital aspect. Shipping is still crucial to international trade, especially for commodities transported in bulks, and serves as a vital factor underpinning the health of the global economy. Important characteristics of the shipping markets are that they are capital intensive, cyclical, volatile, seasonal, and exposed to the international business environment (Kavussanos & Visvikis, 2006).

The volatile nature of the shipping markets is of concern to several participants in the market. These participants are not only shipowners and charterers but include shipping investors, shipyards, and financiers (Alizadeh & Nomikos, 2011). As Alizadeh & Nomikos (2011) points out, Shipowners and charterers regard the high freight rate volatility as undesirable because of its effect on cash flow and profitability of operations and trade. In addition, financiers are affected since freight rate fluctuations can increase the probability of default on shipping loans. The latter remark makes controlling for freight market risk especially beneficial to shipowners. This is because the shipping sector is characterized by capital-intensive investments, which suggests extensive debt financing where capital costs affect profit (Adland, Ameln & Børnes, 2019). Thereby, lower-risk ships will be rewarded with lower interest rates. This makes the idea of controlling for freight market risk more attractive to the shipowner.

To control freight market risk, agents and participants in the international shipping market have developed and utilized different types of contracts and tools (Adland & Alizadeh, 2018). In this paper, we will look at cleared Forward Freight Agreement (FFA) contracts. FFA contracts are flexible and have virtually no default or counterparty risk when being cleared. It is to be clarified that FFA contracts do not provide access to a vessel or transportation service (Adland & Alizadeh, 2018). FFAs can be used by various market participants and for several reasons. For instance, shipowners and charterers use FFAs for hedging purposes. Shipowners take a short position in an attempt to protect their income from falling freight rates. Charterers, on the other hand, take long positions to cover their cost from freight rate increases. If the freight rates fall below the agreed FFA rate, the buyer (charterers) of the FFAs pays the difference between the agreed FFA contract price and the settlement price. If the freight rates end up increasing above the agreed FFA rate, the seller (shipowners) of the FFAs pays the difference between the agreed FFA contract price and the settlement price (Kavussanos & Visvikis, 2016, p. 338).

The shipping derivatives market started trading dry cargo freight futures in 1985 when the Baltic International Freight Futures Exchange (BIFFEX) was established in London. BIFFEX was established to perform as an hedging instrument in the shipping freight market (Kavussanos, Visvikis & Batchelor, 2004). In 1992, FFAs was the first over-the-counter (OTC) freight derivatives product that appeared on the market and was an alternative to BIFFEX to settle better hedges for freight rate risk in the dry bulk and wet bulk sectors. Since the introduction in 1992, the FFA contracts were growing rapidly as the leading derivatives market, offering agents in the shipping and transportation industry a risk management instrument. OTC FFAs are derivative contracts where two parties (shipowner and charterer) must agree to do business with each other while accepting credit risk from the other party (Batchelor, Alizadeh & Visvikis, 2005). FFAs are principal-to-principal contracts between a seller and a buyer to settle a freight or hire rate for a specified quantity of cargo or type of vessel, for usually one or a combination of the major trade routes (Kavussanos & Visvikis, 2016, p. 338). Before 2007, the majority of the dry bulk FFA trading activity was taking place as OTC agreements between the seller and the buyer. Following the financial crisis of 2008, the percentage of cleared transactions increased substantially and counted for 99,5% of all trades in 2014 (Alizadeh, Kappou, Tsounknidis, & Visvikis, 2015)

Forward Freight Agreement Broker's Association (FFABA) serves as an independent association of FFA broking Baltic exchange members. The association aims to promote trading of FFA, and followingly, provide high quality of OTC derivative products, indices used in the freight future industry and ensure high standards of conduct among market participants (Baltic Exchange, 2021a). Furthermore, the association's members are segregated into their respective markets, either dry bulk or tanker. The dry FFABA consists of nine members. However, data applied in the paper is gathered from Braemar Atlantic Securities Limited (BASL), which only accounts for a portion of the market. Therefore, it is important to notice that interpreted results do not cover the entirety of the dry bulk FFA market

The dry bulk trading routes, which serves as the underlying assets of the FFA contracts today, are either from the Baltic Exchange Panamax Index (BPI), the Baltic Exchange Capesize Index (BCI), the Baltic Exchange Supramax Index (BSI), or the Baltic Exchange Handysize Index (BHSI). Regarding the vessels underpinning the indices, they have the following size order:

Capesize > Panamax > Supramax > Handysize (Baltic Exchange, 2021b). The Baltic Exchange publishes timecharter averages for the different vessels daily for the mentioned indices. The averages that are relevant to our thesis are BCI, BPI, and BSI due to our possession of data from the Capesize, Panamax, and Supramax segments. In addition, averages from the Asian market are of interest as well. This includes Baltic Exchange Panamax (BEP) Asia and Baltic Exchange Supramax (BES) Asia. The averages are calculated using the weightings of the different routes included in the respective indices. In the "Baltic Exchange guide to market benchmarks"-report; route specifications, calculation methods, and publishing times are described in detail. Following this, we know that the London publishing of BCI is at 11:00 GMT+1, while BPI and BSI are at 13:00 GMT+1. The publishing of BEP and BES in Singapore is at 13:00 local time in Singapore, which is at 06:00 GMT+1 (Baltic Exchange Services Ltd., 2021, p. 70). The indices may affect the FFA market as information asymmetry is reduced at publication. Following this, it is interesting to assess the liquidity around the times of publications. It is plausible that the trading activity lowers just before the publications and followingly rises with the publication. One thought is that the trading activity is especially high when the spot rates embedded in the FFA prices deviate. It would be interesting to see the patterns of different liquidity measures during the day, especially in regard to the opening, closing, and publishing of the indices.

The freight derivatives market experienced significant developments in terms of electronic trading screens, settlement mechanisms, and clearing processes in the timespan from 2007 to 2014 (Alizadeh et al., 2015). The use of clearing essentially eliminates the credit risk embedded in OTC agreements, as the buyer and seller do not interact with each other directly. Instead, clearing houses stand in the middle, where the clearing house adopts the position of a buyer to every seller and vice versa. Each time a transaction occurs, the buyer or seller will pay an amount or any other form of acceptable security (determined by the clearing house) to the clearing house. This is called the "initial margin" and represents the potential losses on a specific position between the last mark-to-market value and the close-out position. Therefore, the initial margin works as a buffer, which in case of a default, the non-defaulting party will be paid by the clearing house (Alizadeh & Nomikos, 2009. P. 141). Being able to eliminate credit risk from a transaction by paying an amount of money to this central counterparty, is deemed essential for trades to take place, particularly in the post-2008, after-crisis environment (Kavussanos & Visvikis, 2014). Due to the variety of FFA contracts, the initial margins will differ, as they depend on the volatility of the position, market liquidity, and the maturity of the position (Alizadeh & Nomikos, 2009. P. 141). FFA contracts for dry bulk FFAs are either cleared through Europe Energy Exchange (EEX) or Singapore Exchange (SGX) (Baltic exchange, 2021c). Furthermore, SGX claims to be the largest clearing venue for dry bulk freight, as they recently reported a 60% market share globally (Singapore Exchange Limited, 2021).

Information on the existence of liquidity risk in the FFA market is vital for clearing houses, as they calculate the required margins for clearing FFA contracts by considering the liquidity of the underlying asset. Although the main driver for initial margin levels is the volatility of the underlying asset, limited liquidity also has a significant impact on setting margin curves due to the higher potential slippage effects and costs of closing contracts in the case of default. Low liquidity has an indirect impact on the freight rate volatility, as it implies larger price movements for relatively large orders. Therefore, clearing houses may require a higher initial margin. Followingly, precise information on the nature and behavior of liquidity is essential for setting margin curves, for the alteration of the available contract maturities, or any other features, such as the contract settlement process (Alizadeh et al., 2015).

Transaction costs are an important consideration to the investor and his/her investment decision. Brokers match bid and ask contracts, and the price charged for this service is known as the Bid-ask spread (BAS) - the difference between the bid and asked price per contract. The difference is typically regarded as compensation to brokers for providing liquidity services in a continuously traded market. Therefore, it is viewed as a function of the operational efficiency of the brokers and the nature of the product. Followingly, a lower BAS is considered "better". As BAS is a part of transaction cost, it is of important consideration since the low cost of trading is a rationale of the derivatives markets existence (Batchelor et al., 2005). BAS is typically considered the most important variable reflecting liquidity in financial and commodity markets. Bid and ask prices are posted by market makers, who are prepared to trade at these prices at any point in time, and continuously adjusting them according to market conditions, volatility, liquidity, and trading depth (Alizadeh et al., 2015).

In this thesis, we will investigate potential intraday liquidity patterns in the dry bulk FFA market. We expect to find patterns with connections to opening, closing, and publishing times, in addition to a relationship between the liquidity measures applied. The liquidity measures used to unveil potential patterns are BAS, price quote volatility, and volume. To perform such analysis, we have retrieved FFA contract data from BASL. More specifically for the Capesize, Panamax, and Supramax segments. Due to the lack of studies on intraday data from the FFA market, we will apply theories with inspiration from stock markets. However, in the FFA market, the underlying asset is a service rather than a financial or physical asset. Thus, the cost-of-carry relationship between spot and forward prices is not valid (Batchelor et al., 2005). In other words, there is an elementary difference between storable and non-storable commodities. Therefore, applying theories based on stock markets on the FFA market may prove less relevant.

This thesis aims to uncover intraday liquidity patterns for FFA contracts in the Capesize, Panamax, and Supramax segment, respectively and jointly. Similarities and differences are interpreted within and between each segment.

The thesis contributes to the current literature in a new way. The paper conducts analysis using intraday data – which previously have not been possible to retrieve from the FFA market. Our findings will followingly shed the first light on intraday liquidity patterns and behavior. We hope our thesis will pave the way for further analysis within the field of intraday liquidity patterns in the FFA market.

The remainder of the thesis is structured as follows: Section 2 will discuss relevant theories and current findings in the FFA market, as well as intraday findings in different stock markets. In section 3, we present further enlightenment on the retrieval, processing, and application of the data. Furthermore, we present applied methodology and potential weaknesses and limitations of the paper. Section 4 presents and discusses the visual and regression findings, before section 5 provides the concluding remarks.

2. Literature Review

To be able to properly discuss liquidity patterns in the FFA market - a theoretical foundation of key concepts and knowledge will be established in the following segment. The paper will consider three dimensions to uncover liquidity patterns in the FFA market: The bid-ask spread (1), price quote volatility (2), and volume (3). Given our possession of intraday data, we will highlight the dimensions through intraday trading hours.

Given the data at hand, it is interesting to observe BAS and volatility, and assess whether there is a pattern between BAS and volatility. In the current literature, there is a number of studies with different arguments explaining the correlation between volatility and BAS. However, there is an underlying consensus that the two are positively correlated. Batchelor et al. (2005) refer to microstructure theory and three types of costs which BAS must cover for providing immediacy, the right to transact without significant delay (Demsetz, 1968), to the market: inventory carrying costs, asymmetric information costs, and order processing costs. The inventory component should stem from reimbursing market-makers for maintaining open positions or demining liquidity from other participants in the market, which is related to risk. In consideration of this perspective, volatility increases price risk and thereby increases BAS (Bollerslev & Melvin,1994). Moreover, Bessembinder (1994) points out that information asymmetry might positively correlate with price volatility, leading to a widening of BASs.

Out of the three aforementioned components of transaction costs - asymmetric information costs are arguably the most relevant for the FFA market. Given the nature of the FFA market, the shipbrokers do not incur any inventory carrying costs as one does not hold inventory of FFAs. In addition, the order processing costs are relatively low (Batchelor et al., 2005). To our knowledge, there are not many studies on the connection between BAS and volatility in the FFA market. This is at least the case with intraday data, given the difficulties of obtaining them in this market. Therefore, conducting a study on the correlation between BAS and volatility in the FFA market could contribute to the current literature.

Another interesting take on liquidity characteristics, given the intraday data, would be to consider the trading hours. McInish & Wood (1992) analyzed the intraday pattern in BAS for NYSE stocks by examining variables hypothesized to be determinants of the spread. They found a relationship with information, competition, risk, and activity, and concluded that greater transaction demand during the opening and closing hours led to a widening spread.

Their research shows a U-shaped pattern throughout the day. Mishra & Daigler (2014) analyzed intraday trading and BAS characteristics for SPX and SPY options. They found interesting concluding behavior, whereas the BAS and peak institutional volume for SPX options occurs 15-60 minutes after the opening. They state that these results are inconsistent with Admati & Pfleiderer's (1988) informed trading foundation that the average trade size would reflect a U-shaped pattern, which is the case for SPY options. McInish & Wood (1990) conducted tests on volume as well, using transaction data for all stocks traded on the Toronto Stock Exchange. They concluded that the number of shares traded followed a U-shaped pattern, providing further evidence to the existing findings. Other studies on trading hours have been conducted by, for instance, Lockwood & Linn (1990) on the variance of returns on the Dow Jones Industrial Average during the period from 1964-1989. Their results indicate that return variance, thereby market volatility, falls from opening hours to the afternoon and rises thereafter. All aforementioned tests support the notion that BAS, volatility, and volume are U-shaped.

Kalev & Pham (2009) studied intraday and intraweek trading patterns for stocks traded on the Australian stock exchange over a three-month period. They observed that both intraday and intraweek trading activities followed an inverted U-shaped pattern. They found that traders were unlikely to transact at the start of the day or week and instead postponed their transactions. Postponing of transactions was done to obtain more information and therefore being able to reduce their transaction cost. In terms of volume traded, Kalev & Pham (2009) found that traders tend to trade medium size volume when the information cost and liquidity for the asset are low and tend to trade larger volume when information cost and liquidity are high. Furthermore, they discovered that traders trade large sizes near closing time due to more information. Yu, Wu, & Hsieh (2017) examined weekday effects and intraday returns for stock indices. They found that intraday return volatility follows a U-shaped pattern. It rises at the opening before it declines and experiences a flat curve most of the day. Volatility experiences an increasing trend approaching closing time before declining slightly at closing. However, as mentioned in the introductory section, there is an elementary difference between storable and non-storable commodities. Hence, the stock market theories and findings discussed may not hold for the forward freight agreement market.

Alizadeh et al. (2015) refer to the recent growth in the FFA market and how the shipping market virtually mitigated counterparty risk due to the rise of cleared contracts and transparency caused by, for instance, electronic trading screens and different regulatory processes. Furthermore, Alizadeh et al. (2015) showcase that trading volume is the largest and of similar magnitude within Capesize and Panamax FFAs while relatively low for Supramax and Handysize, the last one not being included in our dataset. Moreover, they point out that speculators' trading activity is most likely to be concentrated around Capesize FFAs, due to higher volatility caused by the vessels having a relatively small variety of commodities. The discourse of Alizadeh et al. (2015) sheds light on differences between the different vessel sizes' FFAs. Our thesis will consequently want to enlighten this topic further using the gathered data from BASL.

3. Data and Methodology

3.1 Description of data

The original dataset for which the applied dataset is constructed contains monthly, quarterly, and yearly contracts obtained from BASL The data is provided by Zuma labs, which serves as a web-based platform for OTC physical and derivatives markets and facilitates the entire brokerage process from quote to clearing for BASL (Hellenic Shipping News, 2020). According to Adland & Alizadeh (2018), the quarterly and yearly contracts are the most liquid, which coincides with the observations in our dataset. However, the quarterly contracts have the most observations, and followingly the finalized dataset will be based on these. The quarterly FFA contracts contain three different dry bulk carriers: Capesize, Panamax, and Supramax. It is worth mentioning that the gathered data extends from mid-2019 to mid-March 2021. However, the applied data will be from 01.01.2020 due to significantly less frequent intraday observations prior to this date.

The dataset contains information about the type of vessel and whether the individual observation is a *bid*, *ask*, *transaction* or *midpoint*. In addition, price and date with the corresponding timestamp down to the second is provided. If the individual observation is a transaction, the related contract volume is provided. Further, we separate each vessel's FFA data into three different data sets: 1) we have compiled sets for *bids* and *asks* for quarterly FFA contracts to calculate bid-ask spread, 2) we have sets for *midpoint* prices, which contain the average prices between the corresponding bid and ask for each time a new bid-ask spread occurs, and 3) we have sets for *transactions* with data for agreed price and volume for each trade. The bids and asks for quarterly FFA contracts and their respective midpoint averages are facilitated through the brokerage process at BASL. The transaction data are from when they are reported from BASL to a clearing house. However, the obtained transaction data only consist of transactions cleared through EEX. A weakness in the dataset is that there exists a reporting lag of the transactions, as the brokers are required to report the transactions to the clearing house within fifteen minutes. Followingly, we may incur problems delegating transactions to the correct time intervals.

To examine intraday characteristics, we have divided each trading day into 30-minute intervals. From this, we obtain 24 time intervals, beginning at 05:00 GMT+1 and ending at 17:00 GMT+1. BASL provides shipbroking services throughout the day, but there is a lack of activity during the evening/night. In addition, the Baltic Exchange publishes today's forward curves and volatilities at 17:30 GMT+1. Followingly, BASL must submit their estimated mid-price assessment of the bid and ask quotes for that specific day by 17:00 GMT+1 (Baltic Exchange, 2021d). Therefore, we exclude observations after 17:00 GMT+1 from our samples. An overview of the different time intervals and their corresponding names (D1, D2...D24) are provided in Table A.1.2. We want to look at characteristics occurring at the publishing of Baltic Exchange indices for Singapore and London. For Singapore, index publishing only occurs for Panamax and Supramax, publishing at 13:00 Singapore-time (06:00 GMT+1). The publishing times for London apply to all vessel sizes, with some differences. Capesize publishes at 11:00 GMT+1, while Panamax and Supramax publish at 13:00 GMT+1.

Due to the structure of FFA contracts, each quarterly contract has different maturity intervals (time to maturity). The first-to-expire contract is usually referred to as the front-quarter and will be referred to as maturity 1 in this submission. The next-to-front expire contract is denoted as maturity 2 in this submission. Therefore, each quarterly contract will consist of two levels of maturity. When a FFA contract expires, the next-to-front becomes the front-quarter contract, and this implies that all contracts shift by one position. This shift is called the *rollover* (Geman, 2009, p. 10). As FFA contracts move into the delivery quarter, the trading volume shifts to the contract with the next-to-front delivery date. Therefore, hedgers and long-term speculators tend to take new positions to avoid higher transaction costs when the contract shifts from a next-to-front to a front-month contract (Grammatikos & Saunders, 1986). To illustrate when this rollover date occurs, we have looked at trading activity close to this "expiration date" to see when the trading activity for all vessel sizes declines. We further use this as our rollover date. We performed a visual analysis on Figure 1 and decided that the rollover date applicable to our dataset is the 20. of the first month within the following front-maturity. The data used to create Figure 1 is midpoint observations from the first month within the following front-maturity. The quarterly contracts used are Q220, Q320, Q420, and Q121. Contracts after Q121 are excluded from the visual representation as there is a lack of observations in the last month within the corresponding front-quarter contract. Table A.1.1 displays the contracts we use in our analysis, in addition to their respective maturities. Furthermore, Figure 1 is a collection of observations from all three vessel sizes. The noticeable dips in the first part of the month can be explained by weekends with no observations in the quarterly contracts with the most observations.

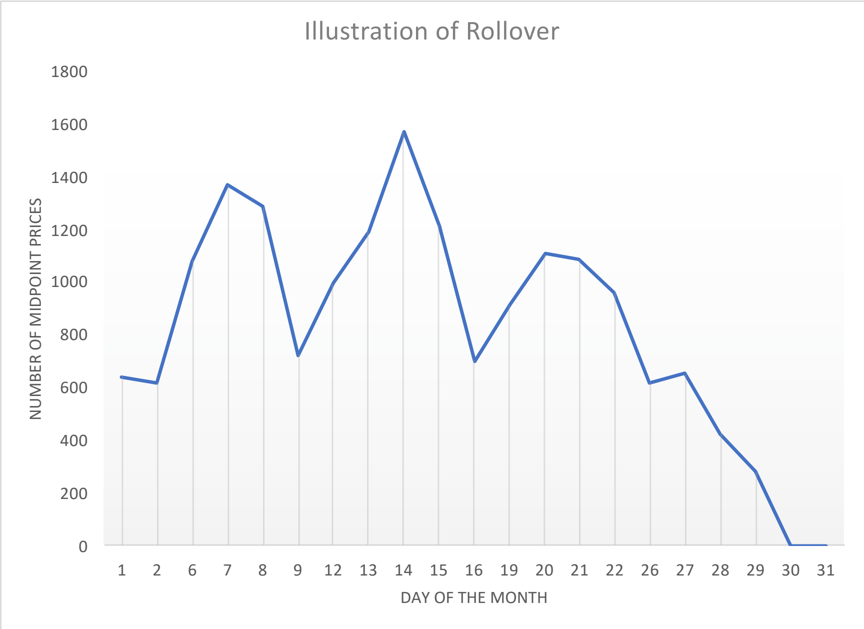

Figure 1: "Illustration of Rollover using number of midpoint prices - All vessel sizes"

Source: Braemar Atlantic Securities Limited

3.2 Measuring liquidity

3.2.1 Bid-Ask Spread

To observe intraday BAS, we have followed the methodology of Mishra & Daigler (2014). First, we have derived the best bid and ask quotes for each minute, each day for each quarterly contract. These best bids and asks are further calculated into percentage terms of BAS, using the following formula retrieved from Batchelor et al. (2005):

$$\frac{(Ask_i - Bid_i)}{\left(\frac{(Ask_i + Bid_i)}{2}\right)}$$

These minute-by-minute absolute spreads are further averaged into 24, 30-minute intervals for each trading day.

3.2.2 Price quote volatility

The volatility measure is based on standard deviations calculated from the midpoint datasets. The midpoint datasets contain the averages of corresponding bid and ask quotes, where a new midpoint price is created every time a change in bid or ask occurs, and is calculated by the following formula:

$$\frac{(Ask_i + Bid_i)}{2}$$

A standard deviation is calculated for each 30-minute interval per day, using the following formula:

$$SD = \sqrt{\frac{\sum(P_i - \overline{P})^2}{(N-1)}}$$

Where P_i denotes midpoint price for observation i.

3.2.3 Volume

The volume measure is calculated using the transaction datasets. The transaction datasets contain lines with prices of actual trades executed, which are retrieved from EEX. Due to few observations in the transaction datasets, the contract volume per transaction can affect predicted values significantly. Therefore, we treat each transaction as only one contract, leading to volume being displayed as number of transactions. Furthermore, volume is averaged for each 30-minute interval per day.

3.2.3.1 *Trading Activity*

McInish & Wood (1992) and Kalev & Pham (2009) investigate intraday patterns in stock markets and refers to number of transactions as trading activity. Following this definition, the volume measure described above can be defined as trading activity. However, we want to treat midpoint prices as a proxy for trading activity to investigate intraday patterns further due to few observations of transactions. Because a new midpoint price is created every time a change in bid or ask occurs, there are more observations and potential information that can enlighten the topic of liquidity further. The midpoint prices are averaged for every 30-minute time interval per day, for each vessel size and maturity level, individually.

3.3 Descriptive statistics

Alizadeh et al. (2015) shed light on the topic of vessel size. The paper points out that trading activity is the largest and of similar magnitude between the Capesize and Panamax FFA contracts while relatively minor for Supramax. Furthermore, speculators' trading activity is most likely to be concentrated around Capesize FFAs, due to higher volatility caused by the vessel size having a relatively smaller variety of commodities. Both aforementioned points are evident in Table 1, as number of observations is of similar magnitude between Capesize and Panamax, and significantly higher than Supramax, as well as volatility proving higher for Capesize than both Panamax and Supramax Table 1 presents the average of the 24, 30-minute interval averages throughout the day for each sub-set, based on the different liquidity measures. Furthermore, Alizadeh (2013) suggests that there may be a positive relationship between standard deviation of returns and vessel size, meaning that FFA prices for larger vessels are more volatile than those of smaller ones. Our descriptive statistics are not clear on this statement as Supramax has higher volatility than Panamax. However, it is to be mentioned that this paper calculates standard deviation of price, not returns. Furthermore, Alizadeh's (2013) research paper provides information on a well-renowned characteristic in the forward freight market, called "volatility term structure". The characteristic suggests that the volatility of FFA prices declines as the maturity of the contract increases. However, it is to be mentioned that this characteristic is evident in bid-ask quotes for closing prices. Therefore, this might not be a present characteristic for intraday bid-ask quotes. Following the notions in this segment, we have divided the dataset into categories of type of vessel and maturity. The sub-sets of the data will be Capesize maturity 1, Capesize maturity 2, Panamax maturity 1, Panamax maturity 2, Supramax maturity 1, and Supramax maturity 2. The volatility term structure and the notion of more volatility in Capesize than Panamax are in accordance with our descriptive data. However, the suggestion of a positive correlation between vessel size and price volatility is not evident.

Table 1

Descriptive statistics - Average values of liquidity measures per sub-set						
	Capesize		Panamax		Supramax	
	Maturity 1	Maturity 2	Maturity 1	Maturity 2	Maturity 1	Maturity 2
Bid-ask spread	0.02350	0.02095	0.01705	0.01764	0.02190	0.02254
Observations	4057	3645	3797	3610	2372	2248
Volatility	92.22250	53.51188	40.89817	34.59612	71.50688	37.50581
Observations	2819	1633	2719	1653	842	591
Volume	1.59570	1.43634	1.64696	1.46053	1.34720	1.22727
Observations	1349	809	1742	1140	625	287

To test the statistical significance for the 30-minute intervals, we have established ordinary least square regression models for the three vessel sizes. The idea for all regression models is to look at dummy variables in opening hours, around Index publishing in Singapore, around publishing in London, and our closing period. Since there exists no publishing time for Capesize in Singapore, we will look at the intervals that coincide with the publishing times for Panamax and Supramax to assess the behavior of Capesize. The same methodology will apply to the different publishing times in London. In other words, when Capesize publishes, we want to look at the behavior of Panamax and Supramax. When the same two vessel sizes publish two hours later, we want to look at the behavior of Capesize.

Therefore, we will use the following model when conducting regressions for BAS, volatility, and volume, where γ_t denotes the variable of interest. For each variable of interest, we estimate two models to cover maturity 1 and maturity 2. β_0 denotes the constant, and β_1 to β_{24} denotes the coefficients for the dummy variables. δ_1 to δ_{24} denotes the dummy variables representing the different time intervals. The time intervals not included as dummy variables in the regression below serve as the benchmark group that makes up the constant (Wooldridge, 2016, p. 208). The mentioned group serves as the base for which the dummy variables are compared. If γ_t is from the time interval represented by δ_i, the dummy will take a value of 1. Otherwise, it will take the value of 0. ε_t denotes the random error for the model.

$$\gamma_t = \beta_0 + \beta_1\delta_1 + \beta_2\delta_2 + \beta_3\delta_3 + \beta_{12}\delta_{12} + \beta_{13}\delta_{13} + \beta_{16}\delta_{16} + \beta_{17}\delta_{17} + \beta_{23}\delta_{23} + \beta_{24}\delta_{24} + \varepsilon_t$$

Averages of BAS, price quote volatility, and volume per time interval is showcased in Table A.2.1, A.2.2, and A.2.3.

3.4 Limitations and weaknesses

This paper has several weaknesses due to the novelty and limited access to intraday data in the FFA market. Firstly, this paper has based its analysis on data obtained from BASL. However, it is important to notice that BASL is not the only company providing dry bulk FFA broking services. Hence, results are most likely not generalizable as they do not reflect more than a portion of the market. Furthermore, the dataset with transactions only contains contracts cleared through EEX. However, EEX shares the dry bulk Freight market with SGX, which recently reported a 60% market share (Singapore Exchange Limited, 2021). Followingly, the applied data does not reflect the whole market. The dataset with transactions has limited observations, which could deem results from regressions and investigation of illustrations insufficient. In addition, brokers are required to report transactions to clearing within fifteen minutes. Thus, a reporting lag exists, which could affect the regressions in this paper.

Many of the decisions made in this paper can affect the outcome. For instance, we observed that the intraday data were less frequent and potentially of less quality in the earlier stages. Followingly, observations prior to 2020 are excluded. This leads to smaller data samples with a shorter time span. BASL provides brokerage services outside of the treated opening and closing hours in this paper. However, due to few observations at earlier and later hours, subjective decisions were made, leading to further exclusion of data. Regarding the rollover date, there was no formal date to apply as a basis. Followingly, subjective decisions were made based on visual analysis. A natural downside of a rollover date is the exclusion of observations. In regard to measures of liquidity, several measurements could be used as a basis. Furthermore, decisions within the measures applied can differ. For instance, volatility can be calculated in several ways, depending on the best fit of the specific situation. This, like other decisions, affects the outcome of the paper's results.

Due to the novelty of access to intraday data in the FFA market, theory and empirical evidence from stock markets are used as a basis for discussion. However, as the nature of the underlying assets differs between the markets, they are not necessarily comparable.

4. Analysis, Results, and Discussion

This section will present illustrations and regression analysis for the different liquidity measures mentioned, for all vessel sizes and their respective maturity levels. Firstly, we will present and investigate the potential intraday patterns for each liquidity measure and look at differences between vessel sizes and maturity levels. Furthermore, we will examine the differences for specific time intervals with regression analysis. Specifically, we want to look at opening, publishing times for Singapore, the different publishing times for London, and the closing period before reported bid and ask quotes must be submitted to the Baltic Exchange. Further, we want to test BAS and volatility against one another to see if there is a significant relationship between the two liquidity measures. Lastly, we have divided all intraday time intervals into two groups. The first group contains the twelve first time intervals, representing every time interval before BCI publishes. The second group will represent the intervals after the London indices come into play to see if there are any significant differences in BAS, volatility, or volume when comparing the two groups. All intraday plots are created by the mean values for each time interval.

First, the paper presents its findings from illustrations and regressions in terms of BAS. Secondly, the results from volatility are showcased, before volume is presented. Thereafter, a discussion of the liquidity measures in light of theory and previous empirical evidence takes place.

4.1 Bid-Ask spread

We want to examine patterns and behavior of BAS throughout the day, across different vessel sizes and maturity levels. Followingly, we have conducted regressions which can be observed in Table 2. In addition, we have created Figure 2 to illustrate intraday patterns in the mentioned subsets. The regressions highlights opening, closing, and publishing, while the figure depicts BAS averages for all the different time intervals.

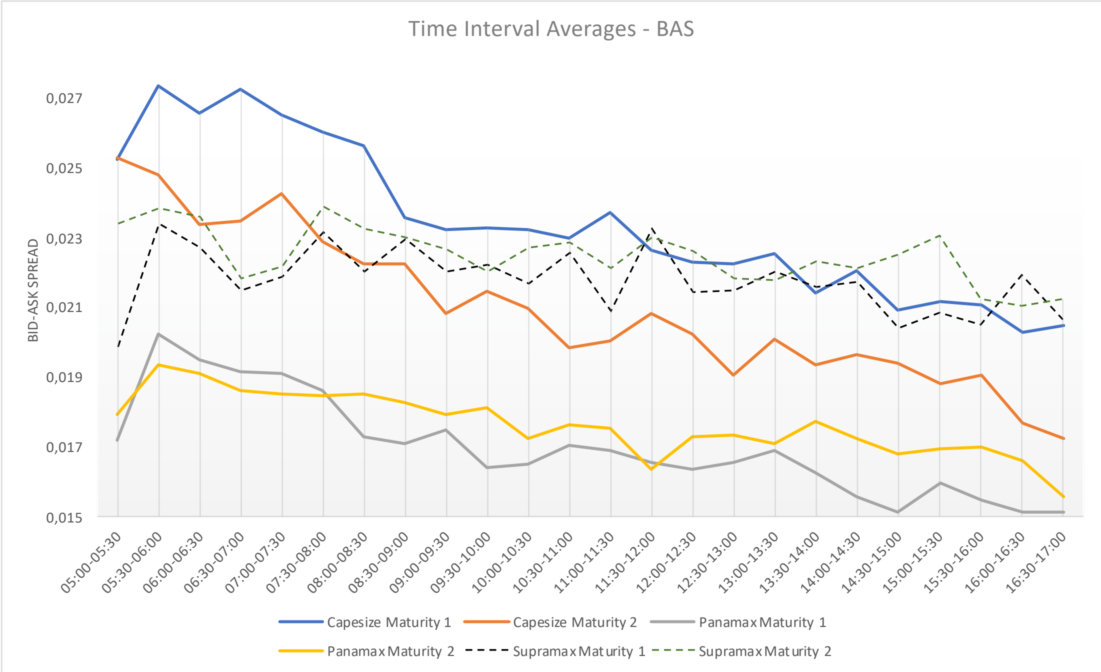

Figure 2: "Time Interval Averages - BAS"

Source: Braemar Atlantic Securities Limited

By observing Figure 2, it is clear that a downward trend is present. This seems to be the case for both Capesize and Panamax. However, by studying Supramax, a pattern is not as obvious. In addition, it is evident from Figure 2, Table 1, and Table 2 that the Panamax segment has better (lower) BAS values than the other vessel sizes. To further assess Capesize, we can examine Table 2. D1 and D2 have positive and significant coefficients, while D23 and D24 are significantly negative for both maturities. This provides further suggestion to a downward trend throughout the day for the Capesize segment. The same can be observed in Figure 2 and Table 2 for Panamax maturity 1 and 2. However, D1 is not significant. There is no clear indication of a trend in the Supramax segment. The observed downward trend for two of the vessel sizes may be due to information reaching the market. This can be the case due to the publishing of the different indices in both Singapore and London.

Regarding publishing of the BEP and BES indices in Singapore at 06:00 GMT+1, we can observe in Table 2 that BAS right before publishing is substantially higher than the daily average for Capesize and Panamax, across both maturity levels. As BEP and BES publish, we observe that BAS improves for Panamax and that Capesize is affected by the same improvement, even though the publishing of BEP and BES do not apply directly for this vessel size. Regarding Supramax, we cannot justify the same improvement in terms of BAS around the publishing of BEP and BES.

The publication of BCI at 11:00 GMT+1 has varying effects on the different vessel sizes and maturity levels, where the impacts are mostly insignificant. However, Capesize maturity 2 has negative and significant coefficients corresponding to the publication. As for the publication of BPI and BSI, there are only significant (negative) coefficients for Capesize maturity 1 and 2, even though the publications should not affect this segment directly. By inspecting the coefficients corresponding to the London publishing of indices, there is little evidence of publishing affecting BAS. However, BAS is lowering throughout the day as the indices are published, indicating a delayed effect.

As priorly discussed, there is a suggestion of a falling trend throughout the day. Figure 2 and Table 2 suggest that this is the case for Capesize and Panamax. To further investigate these findings, we divide time intervals into two groups; Singapore and London. The Singapore group consists of BAS observations from 05:00 GMT+1 until 11:00 GMT+1, while the rest of the observations until closing are treated as the London group. In other words, the observations are separated at the publishing of BCI. A regression with London denoted by D1 is conducted, and is found in Table A.4.1. The regressions provide further evidence that BAS after the London introduction is significantly lower for all vessel sizes and maturities. Even Supramax is significant at a 5% level for both maturities, which were not evident in Table 2.

Batchelor et al. (2005) found in their study that there is a positive relationship between BAS and volatility. Followingly, we performed a simple OLS on BAS and price quote volatility, which can be found in Table A.4.2. We discovered a positive and significant relationship for Panamax and Supramax. However, no correlation was found for the Capesize segment. Based on the results, we would expect price quote volatility for the Panamax and Supramax segments to have a similar trend to the ones observed in BAS.

Table 2

OLS estimates of intraday Bid-Ask Spreads

		Capesize		Panamax		Supramax	
		M1	M2	M1	M2	M1	M2
D1							
	β	0.00176	0.00417	0.00025	0.00025	-0.00204	0.00082
		(0.00089)	(0.00074)	(0.000618)	(0.00069)	(0.00105)	(0.00108)
		[1.972]**	[5.661]***	[0.412]	[0.357]	[-1.944]*	[0.757]
D2							
	β	0.00388	0.00370	0.00333	0.001632	0.00150	0.00123
		(0.00080)	(0.00068)	(0.00051)	(0.00055)	(0.00072)	(0.00075)
		[4.870]***	[5.478]***	[6.555]***	[2.949]***	[2.082]**	[1.645]
D3							
	β	0.00311	0.00226	0.00259	0.00142	0.00082	0.00102
		(0.00077)	(0.00063)	(0.00056)	(0.00061)	(0.00088)	(0.00092)
		[4.055]***	[3.608]***	[4.590]***	[2.315]**	[0.931]	[1.108]
D12							
	β	-0.00048	-0.00128	0.00013	-0.00007	0.00066	0.00028
		(0.00073)	(0.00057)	(0.00047)	(0.00051)	(0.00075)	(0.00078)
		[-0.663]	[-2.247]**	[0.278]	[-0.139]	[0.883]	[0.364]
D13							
	β	0.00028	-0.00108	-0.00002	-0.00018	-0.00104	-0.00047
		(0.00070)	(0.00057)	(0.00049)	(0.00053)	(0.00071)	(0.00075)
		[0.393]	[-1.964]**	[-0.041]	[-0.336]	[-1.464]	[-0.630]
D16							
	β	-0.00121	-0.00206	-0.00037	-0.00036	-0.00041	-0.00076
		(0.00072)	(0.00057)	(0.00049)	(0.00055)	(0.00074)	(0.00079)
		[-1.680]*	[-3.593]***	[-0.755]	[-0.661]	[-0.560]	[-0.966]
D17							
	β	-0.00091	-0.00104	-0.00003	-0.00060	0.00008	-0.00079
		(0.00070)	(0.00055)	(0.00046)	(0.00048)	(0.00074)	(0.00078)
		[-1.302]	[-1.880]*	[-0.074]	[-1.233]	[0.115]	[-1.016]
D23							
	β	-0.00318	-0.00345	- 0.0018	-0.00112	0.00001	-0.00155
		(0.00082)	(0.00062)	(0.00058)	(0.00061)	(0.00129)	(0.00131)
		[3.864]***	[-5.563]***	[-3.123]***	[-1.829]*	[0.011]	[-1.172]
D24							
	β	-0.00298	-0.00389	0.00178	-0.00214	-0.00128	-0.00137
		(0.00090)	(0.00068)	(0.00063)	(0.00063)	(0.00120)	(0.00127)
		[3.298]***	[-5.687]***	[-2.812]***	[-3.417]***	[-1.077]	[-1.080]
Intercept							
	β	0.02348	0.02113	0.01694	0.01772	0.02194	0.02261
		[136.8]***	[152.1]***	[145.1]***	[138.8]***	[116.1]***	[113.5]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5% and 1% level.

4.2 Price Quote Volatility

The same procedure as in the bid-ask spread section will be used to examine patterns in price quote volatility throughout the day. Figure 3 depicts averages of price quote volatility for each time interval, for each vessel size and maturity level. In addition, regression results for each vessel size and maturity level can be found in Table 3. The table highlights opening, closing, and publishing. Additional figures for the individual vessel sizes are included in the appendix due to the overlapping series in Figure 3. These can be found in Figure A.3.1, A.3.2, and A.3.3.

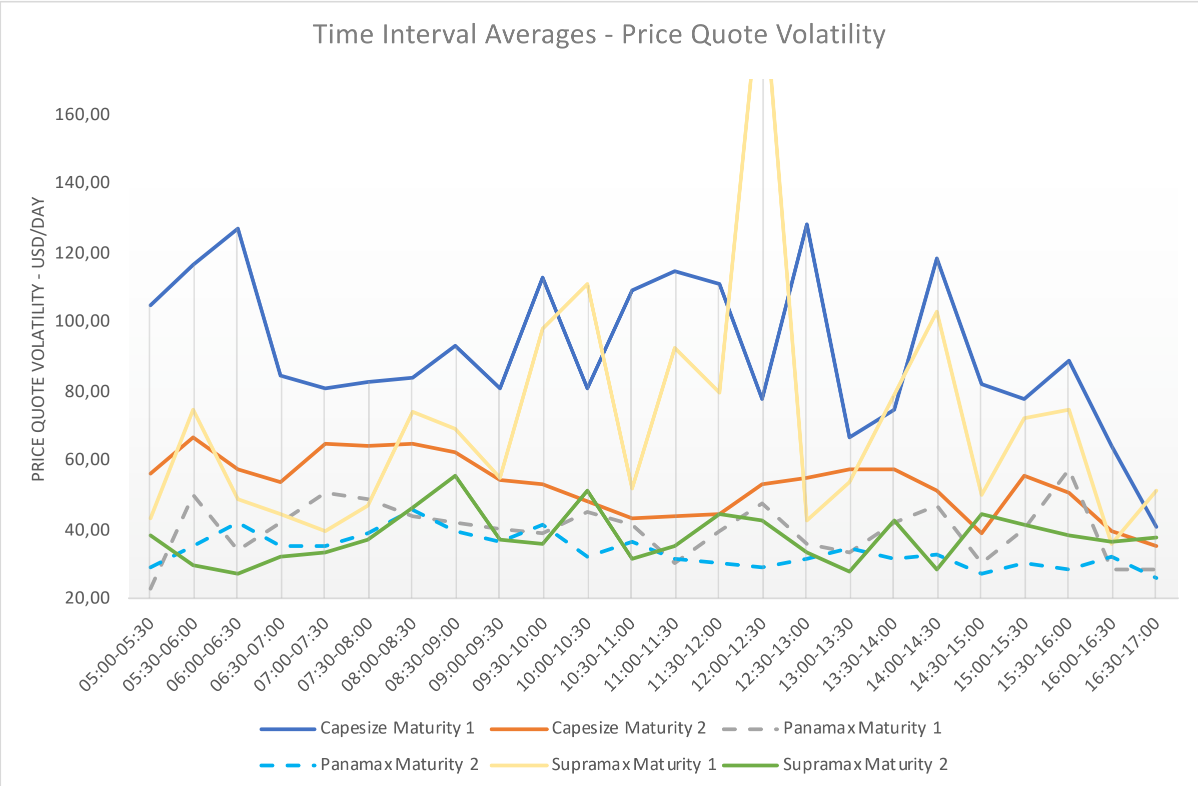

Figure 3: "Time Interval Averages – Price Quote Volatility"

Source: Braemar Atlantic Securities Limited

Compared to BAS, there are no apparent patterns throughout the day for price quote volatility. However, there seems to be a slight decrease in Capesize and Panamax for both maturity levels. This can be observed by investigating Figure 3, A.3.1, and A.3.2. As for the Supramax segment, depicted in Figure 3 and A.3.3, there is a relatively evenly distribution of price quote volatility, except for Supramax maturity 1 at 12:00-12:30 GMT+1. However, according to Table 3, these trends are not present. Maturity 1 for Capesize and Panamax do not have any significant coefficients. However, maturity 2 for the mentioned vessel size has significant negative coefficients towards closing. Further, it can be observed in Figure 3 that the Panamax segment is less volatile than the other two vessel sizes. This is supported by the descriptive statistics in Table 1 and the regression output in Table 3.

Regarding the performed regression analysis between Singapore and London presented in Table A.4.3, we find a significant difference for maturity 2 for both Capesize and Panamax, which can justify a downward trend on a 1% level. We performed a simple OLS regression on BAS and price quote volatility, presented in Table A.4.2. We found a positive correlation between BAS and volatility for Panamax maturity 2. This brings further evidence to the downward trend seen in Panamax maturity 2.

In terms of how price quote volatility behaves around the publishing of indices, the results in Table 3 do not provide many significant coefficients. Regarding publishing for BES and BEP, there is only evidence of volatility for Supramax maturity 2 decreasing right before publishing, and even more after on a 10% level. If we look at London publishing, it can be found that Capesize maturity 2 experiences a significant decrease in volatility before and after the publishing of BCI. Further, we cannot see the other vessel sizes being significantly influenced by the publishing. As for the publishing of BPI and BSI, we experience a significant decrease for Supramax maturity 2 right after publishing. However, no effect on the two other vessel sizes is evident, according to Table 3.

Further, it can be observed in Figure 3 that maturity 1 is continuously more volatile throughout the day for each vessel size, except for sporadic crossings in volatility in the Panamax segment. This is in accordance with the term structure of volatility mentioned by Alizadeh (2013), which suggests that the volatility of FFA prices declines as the maturity of the contract increases. In addition, it provides evidence of the phenomenon existing for intraday bid-ask quotes, and not only bid-ask for closing prices.

Table 3

OLS estimates of intraday Volatility

		Capesize		Panamax		Supramax	
		M1	M2	M1	M2	M1	M2
D1							
	β	16.784	0.7367	-20.277	-6.3571	-34.424	-1.857
		(24.744)	(7.5615)	(11.994)	(5.7195)	(35.981)	(7.460)
		[0.483]	[0.097]	[-1.691]*	[-1.111]	[-0.957]	[-0.249]
D2							
	β	28.567	11.2287	6.658	-0.1686	-3.321	-10.462
		(30.613)	(7.4719)	(9.241)	(3.9914)	(34.577)	(6.310)
		[0.933]	[1.503]	[0.721]	[-0.042]	[-0.096]	[-1.658]*
D3							
	β	39.178	2.5456	-9.386	6.8118	-29.051	-13.410
		(29.904)	(6.3802)	(10.340)	(4.8687)	(40.872)	(7.004)
		[1.310]	[0.399]	[-0.908]	[1.399]	[-0.711]	[-1.915]*
D12							
	β	21.165	-11.7271	-1.746	1.2096	-26.141	-8.669
		(27.623)	(6.0390)	(7.920)	(3.4176)	(34.577)	(6.516)
		[0.766]	[-1.942]*	[-0.220]	[0.354]	[-0.756]	[-1.331]
D13							
	β	26.368	-11.3690	-13.380	-3.5225	14.602	-5.001
		(27.623)	(5.1744)	(8.793)	(3.7847)	(32.233)	(5.956)
		[0.955]	[-2.197]**	[-1.522]	[-0.931]	[0.453]	[-0.840]
D16							
	β	40.051	-0.3444	-7.841	-3.6380	-35.263	-7.240
		(30.613)	(6.3277)	(9.145)	(4.2393)	(35.493)	(6.745)
		[1.308]	[-0.054]	[-0.857]	[-0.858]	[-0.994]	[-1.073]
D17							
	β	-21.471	2.4260	-9.793	-0.4563	-24.066	-12.705
		(29.904)	(5.9517)	(8.136)	(3.3426)	(35.025)	(7.146)
		[-0.718]	[0.408]	[-1.204]	[-0.136]	[-0.687]	[-1.778]*
D23							
	β	-23.937	-15.4840	-14.715	-3.2346	-42.075	-3.928
		(33.898)	(6.6658)	(10.705)	(4.4961)	(62.041)	(9.387]
		[0.706]	[-2.323]**	[-1.375]	[-0.719]	[-0.678]	[-0.418]
D24							
	β	-47.488	-19.7936	-14.973	-9.4903	-26.454	-2.773
		(45.304)	(7.8520)	(11.293)	(4.8095)	(55.135)	(12.696)
		[-1.048]	[-2.521]**	[-1.326]	[-1.973]**	[-0.480]	[-0.218]
Intercept							
	β	88.054	55.0580	43.287	35.0876	77.827	40.278
		[13.14]***	[39.36]***	[22.11]***	[39.88]***	[9.11]***	[23.74]***

Standard errors are illustrated in (), while t-statistics are in [].

*, **, *** Denotes significance level at 10%, 5%, and 1% level.

4.3 Volume

We want to further enlighten liquidity in the FFA market by investigating volume for each vessel size and maturity level. Due to a relatively low number of observations, we employ the number of transactions that occurred per time interval per day. To employ the number of contracts per transaction would deem certain transactions more influential on regressions and illustrations due to abnormal number of contracts. Figure 4 displays averages of daily transactions per time interval for every vessel size and maturity level, while Table 4 contains regression results. Figure 4 is difficult to interpret due to similar averages across vessel sizes and maturities. Hence, illustrations for individual vessel sizes can be found in A.3.4, A.3.5, and A.3.6. In addition, an illustration of total number of transactions per time interval can be observed in Figure 5.

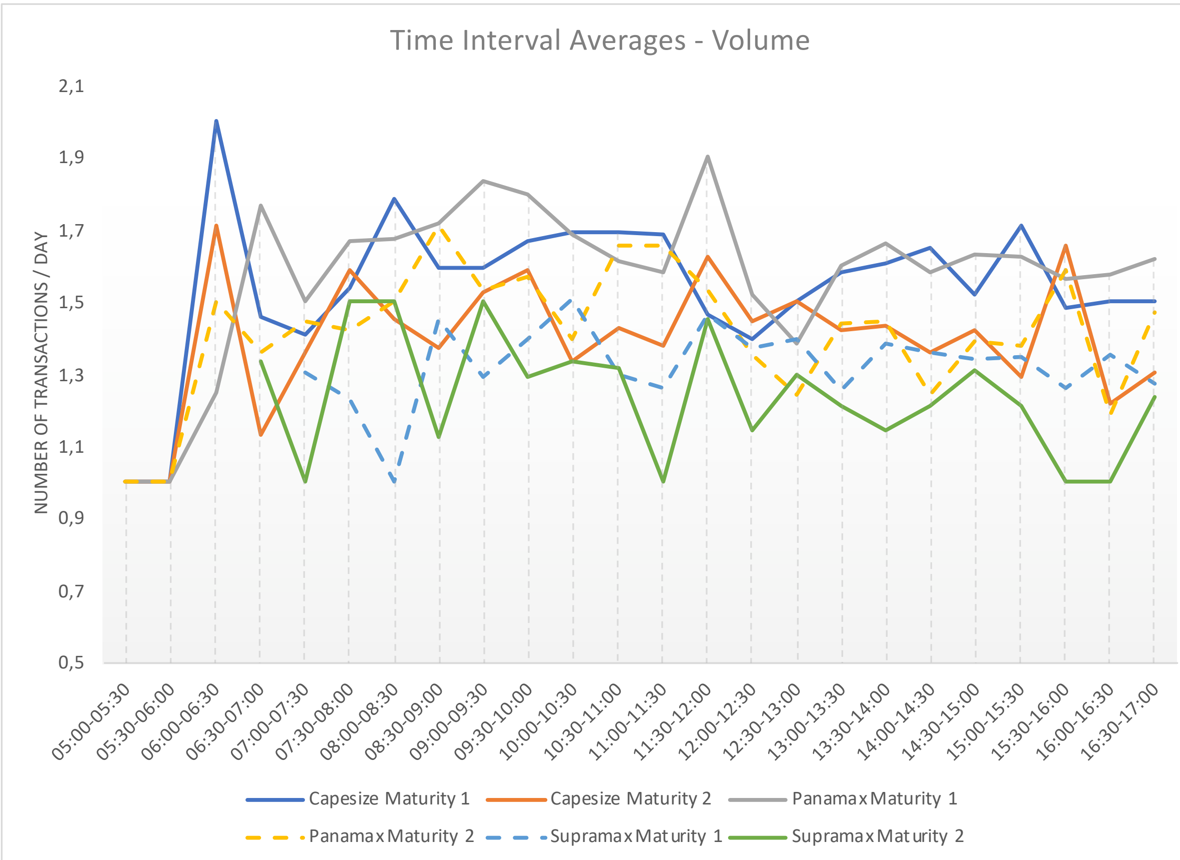

Figure 4: "Time Interval Averages – Volume"

Source: Braemar Atlantic Securities Limited

By observing Figure 4, A.3.4, A.3.5, and A.3.6, there are no particular trends throughout the day in regard to volume. However, there seems to be a lower number of transactions at the beginning of the day for all segments. By observing Figure 5, we see few total transactions for each vessel size and maturity at the beginning of the day. The Supramax segment lacks observations for several time intervals. Furthermore, the figure shows that the total number of transactions increases substantially before reaching a peak between 09:00 GMT+1 and 11:00 GMT+1, depending on vessel size and maturity. This is followed by a steep decrease before the total number of transactions picks up again around the BPI and BSI publishing. Thereafter, another decline is present towards closing time for each vessel and maturity, except for Supramax maturity 2, according to Figure 5.

Regarding volume around the publishing of the different indices, Panamax maturity 2 experiences a significant increase right before BCI publishes at 11:00 GMT+1. After BCI publishing, Supramax maturity 2 experiences a significant decrease in volume. Regarding publishing of BPI and BSI, there is a significant decrease in volume of both maturity levels for Panamax right before publishing at 13:00 GMT+1. Table 4 exhibits justification of volume declining for all maturity 2 levels across all vessel sizes leading up to closing.

From figure 5, containing illustrations of number of transactions throughout the day, we can see a low number of transactions around the publishing of BEP and BES. It is visualized that both maturity levels for Capesize and Panamax increase around publishing in Singapore before reaching their peaks in the hours before BCI publishes. Both Supramax maturities observe only a few sporadic transactions before one or two time intervals after publishing of BES, which is why the illustration does not provide complete lines. After BCI publishes in London, there is a decrease in the number of transactions for all vessel sizes and their respective maturities. This is followed by an increase in the number of transactions as BPI and BSI publish, which is especially evident for Capesize and Panamax on maturity level 1.

Table A.4.4 presents the findings in regard to inspecting differences in volume between the Singapore and London group. Every coefficient suggests a decrease in volume traded from Singapore to London time. However, there are no significant coefficients for the Capesize segment. Panamax experience a decline, which is indicated by a significance level of 10% in maturity 1, and 5% in maturity 2. Supramax maturity 2 has a significant and negative coefficient at a 5% level. By observing Figure 5, it can be observed that the total number of transactions reaches a peak before 11:00 GMT+1. However, the figure displays a stable number of transactions for each time interval after 11:00 GMT+1, while the early hours consist of time intervals with few transactions. Thus, it proves difficult to conclude whether there is a difference in volume between the two.

Alizadeh et al. (2015) stated that speculators tend to revolve around Capesize FFAs due to higher volatility, and further suggested that Capesize freight rates have experienced the highest level of USD trading volume. However, according to Figure 5, Panamax has the highest total number of transactions throughout the day when comparing the maturities individually. To further investigate the notion, we created an illustration taking the total number of contracts per time interval into consideration. The figure can be found in the appendix and is denoted as A.3.7. The difference between A.3.7 and Figure 5 is that A.3.7 accounts for the number of contracts per transaction made. The notion that Panamax is the contract most frequently traded still holds after the investigation.

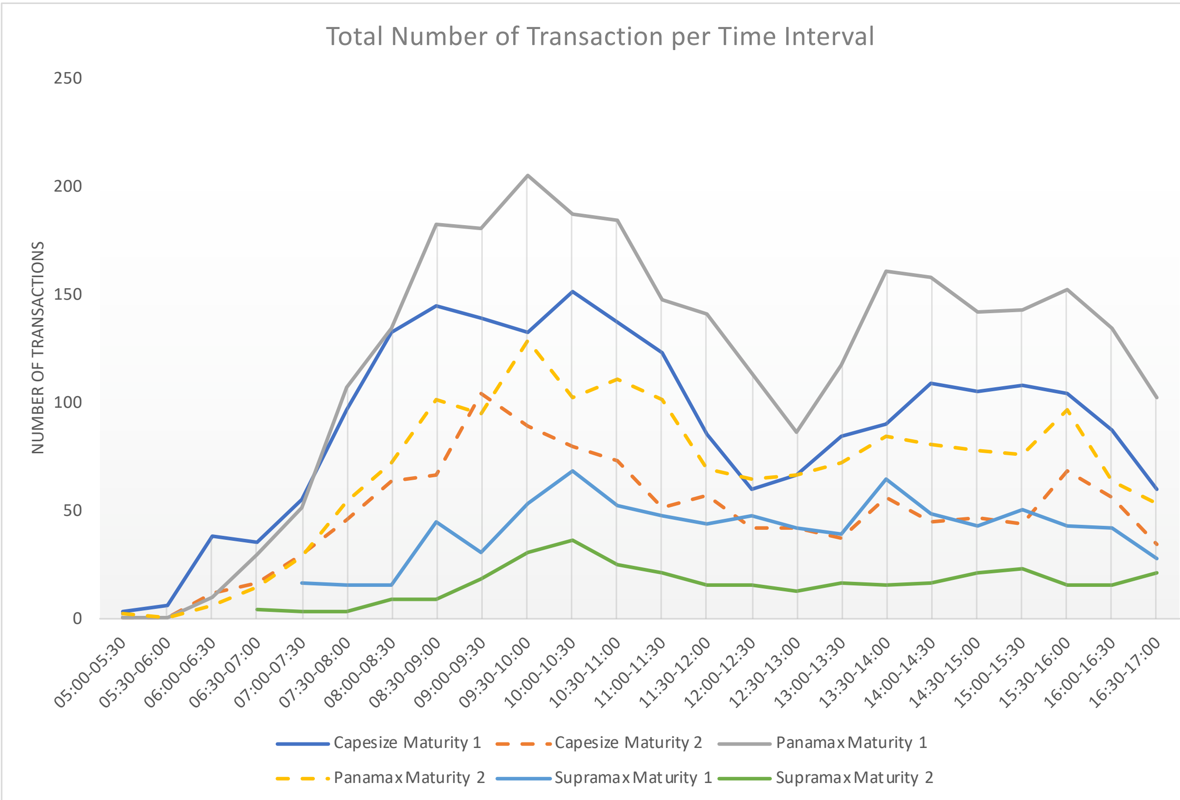

Figure 5: "Time Interval Averages - Total number of transactions"

Source: Braemar Atlantic Securities Limited

Table 4

OLS estimates of intraday Volume

		Capesize		Panamax		Supramax	
		M1	M2	M1	M2	M1	M2
D1							
	β	-0.593202	-0.45904	-068035	-0.468630	-0.36427	-
		(0.590582	(0.86649)	(1.07046)	(0.609185)	(0.69654)	-
		[-1.004]	[-0.530]	[-0.636]	[-0.769]	[0.523]	-
D2							
	β	-0.593202	-0.45904	-068035	-0.468630	-	-
		(0.418247	(0.86649)	(1.07046)	(0.860967)	-	-
		[-1.418]	[-0.530]	[-0.636]	[-0.544]	-	-
D3							
	β	0.406797	0.25524	-0.43035	0.031370	0.63573	-
		(0.236593)	(0.32917)	(0.37953)	(0.431309)	(0.69654)	-
		[1.719]*	[0.775]	[-1.134]	[0.073]	[0.913]	-
D12							
	β	0.098155	-0.02767	-0.06632	0.188086	-0.06427	0.05653
		(0.118121)	(0.12639)	(0.10472)	(0.109533)	(0.11500)	(0.13510)
		[0.831]	[-0.219]	[-0.633]	[1.717]*	[-0.559]	[0.418]
D13							
	β	0.091729	-0.08067	-0.09971	0.187108	-0.10111	-0.25926
		(0.123951)	(0.14675	(0.11504	(0.114386)	(0.11773)	(0.12912)
		[0.740]	[-0.550]	[-0.867]	[1.636]	[-0.859]	[-2.008]**
D16							
	β	-0.093203	0.04096	-0.29326	-0.223347	0.03573	0.04074
		(0.157423	(0.16747)	(0.13924)	(0.122132)	(0.13137)	(0.18215)
		[-0.592]	[0.245]	[-2.106]**	[-1.829]*	[0.272]	[0.224]
D17							
	β	-0.008297	-0.03597	-0.07761	-0.028630	-0.10620	-0.04497
		(0.144070)	(0.17351)	(0.12886)	(0.125516)	(0.12937)	(0.15549)
		[-0.058]	[-0.207]	[-0.602]	[-0.228]	[-0.821]	[-0.289]
D23							
	β	-0.093203	-0.24165	-0.10388	-0.283445	-0.00943	-0.25926
		(0.138056)	(0.13256)	(0.11997)	(0.121068)	(0.12937)	(0.14616)
		[-0675]	[-1.823]*	[-0.866]	[-2.341]*	[-0.073]	[-1.774]*
D24							
	β	-0.093203	-0.15135	-0.06131	0.003592	-0.09154	-0.02397
		(0.164781)	(0.17351)	(0.13819)	(0.146671)	(0.15207)	(0.14214)
		[-0.566]	[-0.872]	[-0.444]	[0.024]	[-0.602]	[-0.169]
Intercept							
	β	1.593203	1.45904	1.68035	1.468630	1.36427	1.25926
		[48.61]***	[50.80]***	[55.34]***	[47.70]***	[40.71]***	[30.84]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5%, and 1% level.

4.3.1 Trading Activity

Trading activity serves as a further extension of volume to compensate and potentially catch patterns that slip by a dataset with few observations. Additional rationale for inspecting trading activity using midpoint prices are provided in section 3.2.3.1. Figure 6 illustrates averages of daily midpoint price observations per time interval. Table 5 provides findings from regressions highlighting opening, closing, and publishing. Figure 7 provides further information by displaying the total number of trading activity per time interval.

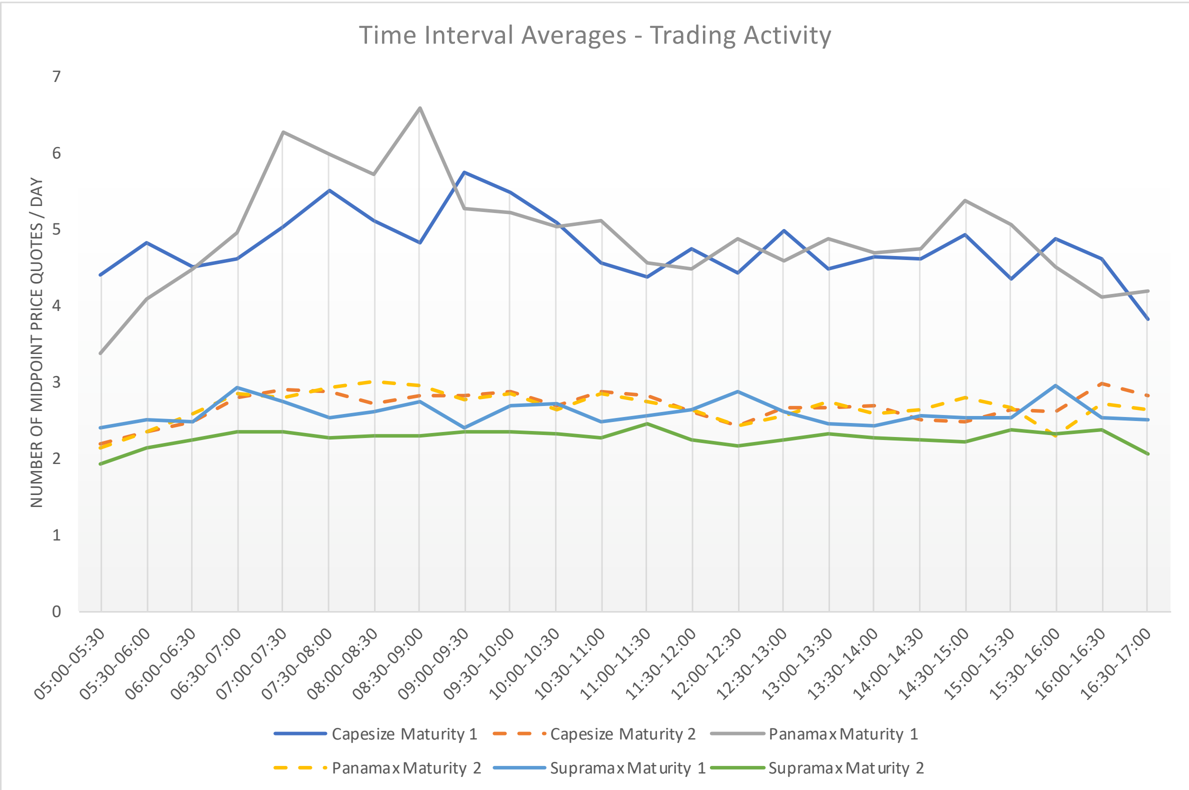

Figure 6: "Time Interval Averages – Trading Activity"
Source: Braemar Atlantic Securities Limited

By observing Figure 6, it can be seen that there is slightly less trading activity at the beginning and end of the day. At least, this seems to be the case for Capesize and Panamax maturity 1. Table 5 generally suggests lower trading activity at opening and closing, and thereby an inverted U-shaped pattern, in terms of coefficients, but do not conclude with the same in terms of significance. However, Capesize maturity 1 has a negative and significant (5%) coefficient at the closing interval. Capesize maturity 2 has a negative and significant (1%) coefficient at the two opening intervals and a positive and significant (5%) coefficient at D23. Panamax maturity 1 displays lower trading activity at opening and closing with significant negative coefficients, while the vessel's maturity level 2 has negative and significant coefficients at the beginning of the day. The only significant coefficient for the Supramax segment is a negative one at opening for maturity 2.

Figure 7 provides further indication of lower trading activity at the beginning and end of the day for the Capesize and Panamax segments. In other words, it displays an inverted U-shape. This is especially evident for Capesize and Panamax on maturity level 1.

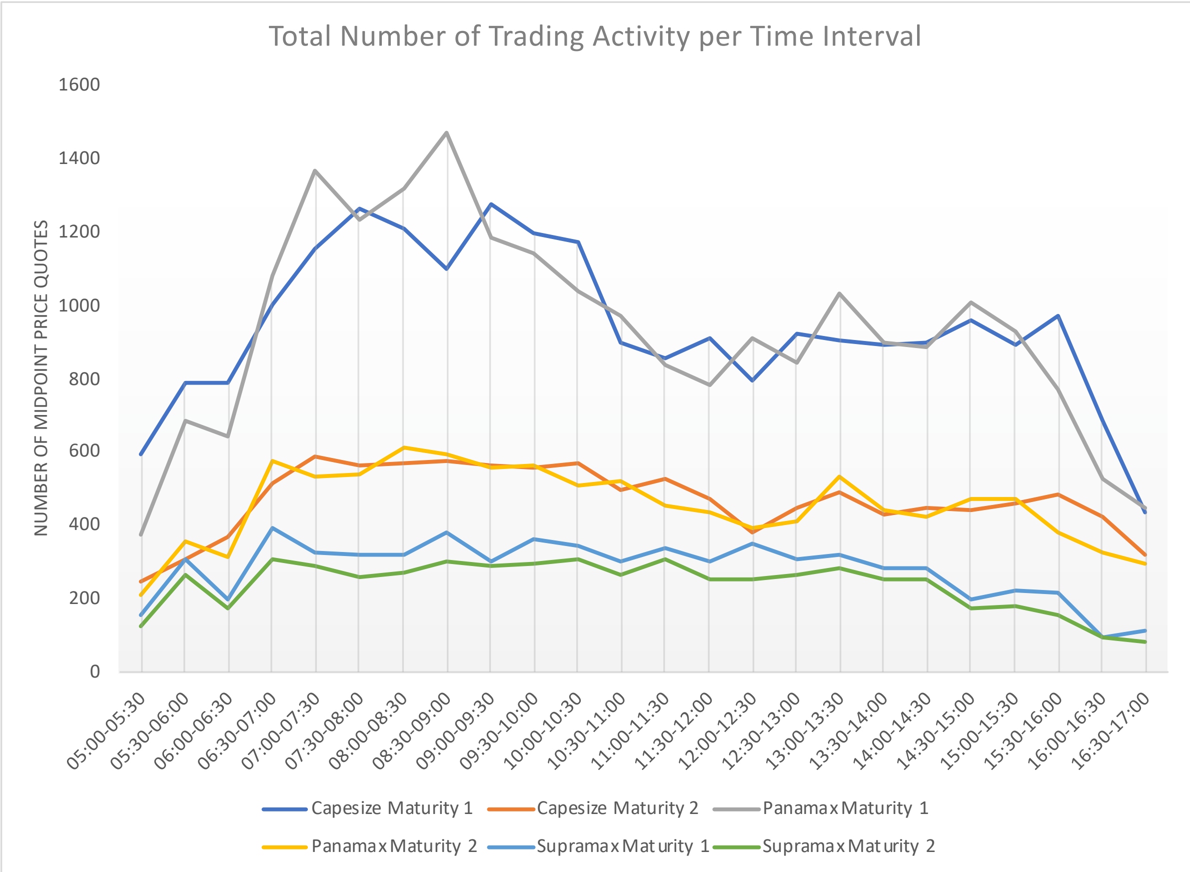

Figure 7: "Time Interval Averages - Total Number of Trading Activity"
Source: Braemar Atlantic Securities Limited

Before the publishing of BEP and BES, both maturity levels for Panamax show evidence of less frequent trading activity compared to the daily average, but show signs of improvement leading up to the publishing at 06:00. This can be found by investigating D2 in Table 5, which shows a negative and significant coefficient with less magnitude compared to D1. In addition, one can observe the increase in Figure 6. The same is evident for Capesize maturity 2. However, the following time interval is negative and significant after the publishing in Singapore as well. In terms of Supramax maturity 2, it is only evident that this level is frequently less traded right after opening. Moving over to publishing of the London indices, it is only apparent that Supramax maturity 2 has significantly higher trading activity compared to the daily average right after the publishing of BCI at 11:00 GMT+1.

Table A.4.5 presents findings in regard to the investigation of differences between London and Singapore time. The results provide evidence that both Capesize and Panamax for all maturity levels have a higher trading activity before BCI publishes at 11:00 GMT+1.

Table 5

OLS estimates of intraday Trading Activity						
	Capesize		Panamax		Supramax	
	M1	M2	M1	M2	M1	M2
D1						
β	-0.56203	-0.52688	-1.83054	-0.60307	-0.24924	-0.36904
	(0.43586)	(0.13982)	(0.52392)	(0.14409)	(0.22367)	(0.12204)
	[-1.289]	[-3.768]***	[-3.494]***	[-4.185]***	[-1.114]	[-3.024]***
D2						
β	-0.11900	-0.35539	-1.13498	-0.38339	-0.15549	-0.14458
	(0.39834)	(0.12979)	(0.42769)	(0.11773)	(0.16460)	(0.08951)
	[-0.299]	[-2.739]***	[-2.654]***	[-3.256]***	[-0.945]	[-1.615]
D3						
β	-0.44436	-0.22088	-0.74708	-0.16413	-0.19299	-0.04733
	(0.38513)	(0.12330)	(0.46029)	(0.13083)	(0.20094)	(0.11099)
	[-1.154]	[-1.791]*	[-1.623]	[-1.255]	[-0.960]	[-1.426]
D12						
β	-0.38089	0.15740	-0.11762	0.11261	-0.16789	-0.03230
	(0.36506)	(0.11416)	(0.40350)	(0.10753)	(0.16523)	(0.09199)
	[-1.043]	[1.379]	[-0.292]	[1.047]	[-1.016]	[-0.351]
D13						
β	-0.57987	0.11431	-0.65498	0.01107	-0.10246	0.15352
	(0.36505)	(0.11006)	(0.41071)	(0.11290)	(0.15867)	(0.08851)
	[-1.588]	[1.039]	[1.595]	[0.098]	[-0.646]	[1.734]*
D16						
β	0.02575	-0.04911	-0.63627	-0.18438	-0.05045	-0.05363
	(0.37514)	(0.11575)	(0.40966)	(0.11455)	(0.16652)	(0.09126)
	[0.069]	[-0.424]	[-1.553]	[-1.610]	[-0.303]	[-0.588]
D17						
β	-0.47197	-0.05170	-0.33084	-0.00105	-0.20165	0.03695
	(0.35991)	(0.11089)	(0.38409)	(0.10439)	(0.15980)	(0.08985)
	[-1.311]	[-0.466]	[-0.861]	[-0.010]	[-1.262]	[0.411]
D23						
β	-0.33235	0.26796	-1.11080	-0.00938	-0.12918	0.07493
	(0.41709)	(0.12535)	(0.48702)	(0.13136)	(0.28816)	(0.15146)
	[-0.797]	[2.138]**	[-2.281]**	[-0.071]	[-0.448]	[0.495]
D24						
β	-1.13143	0.12648	-1.01610	-0.09152	-0.15549	-0.24214
	(0.47279)	(0.14042)	(0.53097)	(0.13578)	(0.26250)	(0.15146)
	[-2.393]**	[0.901]	[-1.914]*	[-0.674]	[-0.592]	[-1.599]
Intercept						
β	4.94722	2.70387	5.21236	2.73438	2.65549	2.29092
	[56.11]***	[98.40]***	[54.20]***	[101.57]***	[62.86]***	[97.83]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5% and 1% level.

4.4 Discussion

This segment of the paper will further discuss observations in figures and results acquired through linear regressions. The observations and findings will be discoursed in light of the literature and theory provided in the literature review.

In terms of intraday BAS, we have previously discussed topics from papers analyzing different stock markets due to the lack of existing intraday literature on the Forward Freight Agreement market. Previous studies conducted by McInish & Wood (1992) and Lockwood & Linn (1990) conclude that BAS follows a U-shaped pattern. As our paper discussed in the introductory section, the FFA market and stock markets are not necessarily comparable due to the different nature of storable and non-storable commodities. However, it provides a fine starting point.

From our findings, we identified that BAS, especially for the Capesize and Panamax segments, contained the highest BAS values at the beginning of the day, and from there on, followed a downward trend to closing. The falling trend is illustrated in Figure 2. The regression analysis displayed in Table 2 provides further evidence of a falling trend from opening until closing, with positive and significant coefficients at opening, and negative and significant coefficients at closing. Even though the illustration and OLS regression exhibited a slight downward trend in the Supramax segment from D2, we cannot draw the same conclusion due to insignificant coefficients. To further investigate the potential differences throughout the day, and more specifically the downward trend, the datasets were split into two groups; Singapore and London. The regression results provided us with significant coefficients, which indicated that BAS values are higher at the beginning of the day compared to after the publication of BCI. Even the Supramax segment provided these results. The bettering of BAS values throughout the day may infer that the market is more efficient as more information flows to the market.

Regarding BAS at opening, our findings for Capesize maturity 2 are consistent with Admati & Pfleiderer's (1988) informed trading foundation, which states that BAS will peak significantly at opening. On the other hand, Mishra & Daigler (2014) found from their intraday analysis of BAS characteristics on SPX and SPY options, that SPX options were inconsistent with Admati & Pfleiderer's (1988) informed trading foundation, and that BAS would peak 15-60 minutes after opening instead. These inconsistent findings of Mishra & Daigler (2014) are present for Capesize maturity 1 and both maturity levels for Panamax.

The publication of indices and their connection to information asymmetry is ambiguous and not straightforward to interpret. Due to higher magnitude and positive correlation at the beginning of the day, the coefficients suggest higher BAS at the publication of Singapore indices (BES and BEP), which is contrary to our hypothesis based on information asymmetry. However, it is to be mentioned that BAS improve from right before publishing to the publication interval for all vessel sizes. This includes Capesize, which implies that BEP and BES publications may indirectly affect Capesize FFAs. As for the publication of BCI, BPI, and BSI, there are few interesting and significant coefficients to discuss. Followingly, there is little evidence of publication of indices affecting BAS by investigating these coefficients directly. However, BAS is lowering throughout the day as the indices are published, which could indicate a delayed effect.

Regarding volatility, we have previously discussed several topics of interest. These include a the potential correlation between vessel size and volatility, presence of term structure of volatility, correlation between BAS and volatility, and the potential U-shaped pattern throughout the day. The illustrations and regressions provided in this paper do not suggest a positive correlation between vessel size and volatility. Capesize contracts are the most volatile, according to Table 1. However, Supramax FFAs have more volatility than Panamax. This is the case when comparing maturity 1 and 2, respectively. This is inconsistent with the findings of Alizadeh (2013). However, the finding in this paper is not necessarily comparable as we calculate price quote volatility and not return volatility. Furthermore, the term structure of volatility is evident in this paper. When comparing maturity 1 with maturity 2, the difference is quite clear, especially in the case of the Capesize and Supramax segments. This is illustrated in Figure 3, A.3.1, A.3.2, and A.3.3.

Regarding the potential positive correlation between BAS and price quote volatility, we conducted a simple OLS with findings displayed in Table A.4.2. Positive and significant coefficients are found for the Panamax and Supramax segment. However, this is not the case for Capesize. Furthermore, we observe in Figure 3 and Table 3 that volatility does not follow a U-shaped pattern throughout the day, as suggested by Lockwood & Linn (1990). However, the illustration suggests some downward trend in volatility for Capesize and Panamax, which would suggest a positive correlation between BAS and volatility. Although, Table 3 displays a lack of significant coefficients. Furthermore, we performed a regression on differences in volatility between the Singapore and London group, similar to the one performed for BAS. Table A.4.3 suggests a downward trend for Capesize and Panamax maturity 2. In conclusion, the findings in this paper indicate a correlation between volatility and BAS. However, there is no clear-cut evidence of BAS and Volatility following the same trend throughout the day.

There are no significant results indicating that volume is consistent with Admati & Pfleiderer's (1988) informed trading foundation - that volume will peak at opening. Nor are there any results in accordance with Mishra & Daigler's (2014) findings for SPX options - that volume peak will occur 15-60 minutes after opening. Even though Figure 4 illustrates that volume for both Capesize and Panamax for all maturity levels experience a spike in volume right after BEP and BES publishing, there is no evidence of this being the institutional peak as volume frequently changes throughout the day. In addition, there is no clear evidence of volume being consistent with Admati & Pfleiderer's (1988) informed trading foundation, and thereby follows a U-shaped pattern. However, the performed OLS regression for volume on London vs. Singapore in Table A.4.4 showed a significant decline for both Panamax maturities and Supramax maturity 2, indicating a downward trend.

Alizadeh et al. (2015) stated that speculators tend to revolve around Capesize FFAs due to higher volatility, and further stated that Capesize freight rates experience the highest level of USD trading volume. This could suggest that the Capesize segment experience a higher trading volume than the other vessel sizes. However, based on the illustration of total number of transactions per time interval in Figure 5, it can be observed that there is a higher number of transactions for Panamax compared to Capesize. The same findings are evident for the total number of contracts per time interval in Figure A.3.7.

Trading activity serves as a further extension of volume due to the volume dataset containing few observations. Figure 6 suggests an inverted U-shaped pattern for Capesize and Panamax on maturity level 1, but the coefficients supporting this notion are only significant for Panamax. However, Figure 7 displays the total number of trading activity per time interval, and suggests an inverted U-shaped pattern for the Capesize and Panamax segments. This is especially evident for Capesize and Panamax on maturity level 1. These observations are in accordance with Kalev & Pham's (2009) findings, that trading activity follows an inverted U-shaped pattern. They concluded that traders were unlikely to transact at the start of the day, and rather postponed transactions to obtain more information and therefore being able to reduce their transaction costs. It is not unlikely that this is the case in the FFA market.

An interesting remark is the Panamax segment in terms of liquidity measures. The BAS values are at the lowest level among the vessel sizes, volatility is generally the lowest, and it contains the highest density of transactions. This could suggest that the Panamax segment is the most efficient of the three vessel sizes considered in this paper.

5. Concluding Remarks

This thesis studies different liquidity measures in the dry bulk FFA market by analyzing intraday data of quarterly contracts obtained from Braemar Atlantic Securities Limited. Through intraday data, we have conducted an analysis previously not accessible on FFA contracts.

To assess possible liquidity patterns in the FFA dry bulk market, we have based our measures on bid-ask spread, price quote volatility, and volume. Most literature on intraday liquidity measures in the stock market suggests a U-shaped pattern throughout the day for the liquidity measures. This is not evident through our analysis of the FFA market. However, we do observe some patterns. Bid-ask spread follows a downward trend throughout the day for each vessel size when comparing the first and second half of the day, and other illustrations and regressions suggest a falling pattern for the Capesize and Panamax segments. Furthermore, trading activity has suggestions of an inverted U-shape, which may be due to traders postponing their transactions to obtain more information and avoid transaction costs. The effect of publications of different indices on liquidity is difficult to interpret by solely investigating the individual time interval coefficients. However, the results justify the assumption that bid-ask spreads are bettering as more information flows to the market through the different publications. In addition, as BPI and BSI are published, Figure 4 displays that the total number of transactions increase for all vessel segments. Furthermore, the paper provides evidence of the existence of term structure of volatility with intraday bid-ask quotes, and provides OLS results suggesting a positive correlation between bid-ask spreads and price quote volatility for the Panamax and Supramax segments.

Our thesis opens for further possible studies of intraday liquidity in the FFA market. As time passes, the potential to gather larger and more efficient intraday data improves, possibly making future studies able to uncover clearer patterns and potentially produce more generalizable results. We believe that conducting studies on intraday liquidity patterns would be of benefit to hedgers, brokers, clearing houses, investors, and other market participants as liquidity is connected to transaction costs and risk management.

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Appendix

A.1 Explanatory tables

A.1.1

Quarterly contract	**Maturity levels**
Q2-2020	Maturity 1/Maturity 2
Q3-2020	Maturity 1/Maturity 2
Q4-2020	Maturity 1/Maturity 2
Q1-2021	Maturity 1/Maturity 2
Q2-2021	Maturity 1/Maturity 2
Q3-2021	Maturity 2

A.1.2

Dummy	**Time-interval**	**Dummy**	**Time-interval**	**Dummy**	**Time-interval**
D1	05:00-05:30	**D2**	05:30-06:00	**D3**	06:00-06:30
D4	06:30-07:00	**D5**	07:00-07:30	**D6**	07:30-08:00
D7	08:00-08:30	**D8**	08:30-09:00	**D9**	09:00-09:30
D10	09:30-10:00	**D11**	10:00-10:30	**D12**	10:30-11:00
D13	11:00-11:30	**D14**	11:30-12:00	**D15**	12:00-12:30
D16	12:30-13:00	**D17**	13:00-13:30	**D18**	13:30-14:00
D19	14:00-14:30	**D20**	14:30-15:00	**D21**	15:00-15:30
D22	15:30-16:00	**D23**	16:00-16:30	**D24**	16:30-17:00

A.2 Descriptive Statistics

TABLE A.2.1

Averages of intraday Bid-Ask Spreads

	Capesize		Panamax		Supramax	
	M1	M2	M1	M2	M1	M2
D1	0.02525	0.02530	0.01720	0.01796	0.01990	0.02343
D2	0.02736	0.02483	0.02027	0.01935	0.02344	0.02384
D3	0.02660	0.02339	0.01953	0.01913	0.02275	0.02363
D4	0.02728	0.02349	0.01917	0.01863	0.02151	0.02186
D5	0.02655	0.02426	0.01910	0.01853	0.02192	0.02220
D6	0.02607	0.02291	0.01864	0.01851	0.02318	0.02393
D7	0.02566	0.02225	0.01732	0.01854	0.02202	0.02329
D8	0.02361	0.02228	0.01712	0.01830	0.02296	0.02303
D9	0.02327	0.02083	0.01748	0.01795	0.02204	0.02271
D10	0.02332	0.02147	0.01644	0.01815	0.02226	0.02204
D11	0.02327	0.02097	0.01653	0.01728	0.02169	0.02275
D12	0.02300	0.01985	0.01707	0.01765	0.02260	0.02289
D13	0.02376	0.02005	0.01692	0.01754	0.02090	0.02214
D14	0.02264	0.02085	0.01656	0.01636	0.02329	0.02301
D15	0.02232	0.02026	0.01638	0.01733	0.02144	0.02262
D16	0.02228	0.01907	0.01657	0.01736	0.02152	0.02185
D17	0.02257	0.02009	0.01691	0.01712	0.02202	0.02182
D18	0.02145	0.01938	0.01628	0.01774	0.02161	0.02236
D19	0.02208	0.01965	0.01559	0.01726	0.02176	0.02213
D20	0.02093	0.01941	0.01516	0.01683	0.02043	0.02256
D21	0.02121	0.01885	0.01597	0.01696	0.02087	0.02306
D22	0.02107	0.01907	0.01550	0.01701	0.02053	0.02125
D23	0.02031	0.01768	0.01514	0.01660	0.02195	0.02107
D24	0.02051	0.01724	0.01516	0.01558	0.02066	0.02124

TABLE A.2.2

Averages of intraday volatility

	Capesize		Panamax		Supramax	
	M1	M2	M1	M2	M1	M2
D1	104.83718	55.79473	23.00948	28.73053	43.40345	38.42133
D2	116.62081	66.28675	49.94476	34.91896	74.50568	29.81599
D3	127.23168	57.60361	33.90041	41.89941	48.77635	26.86798
D4	84.41617	53.74958	41.77608	35.35028	44.16875	32.02285
D5	80.52152	64.56492	50.61464	35.38726	39.58952	33.54706
D6	82.74011	64.31810	48.85479	38.55140	46.78767	37.03851
D7	83.57263	64.47131	43.76196	45.42626	73.83052	46.13427
D8	92.84080	62.25743	41.97565	39.21112	69.16536	55.56157
D9	80.67768	54.42708	39.94736	36.35454	54.95814	36.95791
D10	112.54505	52.95580	38.71569	41.00450	98.08141	35.55841
D11	80.78087	47.90850	45.17771	31.79059	110.64569	51.21769
D12	109.21807	43.33087	41.54121	36.29718	51.68660	31.60869
D13	114.42147	43.68904	29.90718	31.56508	92.42884	35.27743
D14	110.81691	44.18930	39.13930	30.28669	79.20209	44.47795
D15	77.58459	52.96256	47.20340	28.86285	202.68297	42.75513
D16	128.10451	54.71360	35.44620	31.44964	42.56455	33.03788
D17	66.58234	57.48400	33.49421	34.63134	53.76140	27.57332
D18	74.27398	57.37568	42.13575	31.56830	78.57913	42.66171
D19	118.42080	51.30139	46.54366	32.63480	102.72609	28.28462
D20	81.75887	38.59197	30.34529	27.16710	49.97197	44.61321
D21	77.48646	55.66285	39.86604	30.06343	71.82215	41.39283
D22	88.71360	50.48431	57.18807	28.21167	74.55499	38.10255
D23	64.11609	39.57402	28.57200	31.85304	35.75256	36.35037
D24	40.56597	35.26438	28.31416	25.59731	51.37362	37.50517

A.2.3

Averages of intraday volume

	Capesize		Panamax		Supramax	
	M1	M2	M1	M2	M1	M2
D1	1.00000	1.00000	1.00000	1.00000	1.00000	-
D2	1.00000	1.00000	1.00000	1.00000	-	-
D3	2.00000	1.71329	1.25000	1.50000	2.00000	-
D4	1.45833	1.13333	1.76471	1.36363	-	1.33333
D5	1.41026	1.36364	1.50000	1.45000	1.30769	1.00000
D6	1.53968	1.58621	1.67188	1.42105	1.23077	1.50000
D7	1.78378	1.45455	1.67500	1.50000	1.00000	1.50000
D8	1.59340	1.37500	1.71698	1.71186	1.45161	1.12500
D9	1.59770	1.52941	1.83673	1.53225	1.29167	1.50000
D10	1.67088	1.58920	1.79824	1.57317	1.39474	1.29167
D11	1.69662	1.33333	1.68468	1.39726	1.51111	1.33333
D12	1.69135	1.43137	1.61404	1.65672	1.30000	1.31579
D13	1.68491	1.37838	1.58065	1.65574	1.26316	1.00000
D14	1.46551	1.62857	1.90541	1.53333	1.46667	1.45455
D15	1.39535	1.44828	1.52000	1.35417	1.37143	1.14286
D16	1.50000	1.52222	1.38710	1.24528	1.40000	1.30000
D17	1.58491	1.42308	1.60273	1.44000	1.25806	1.21429
D18	1.60714	1.43590	1.65979	1.44828	1.38298	1.14286
D19	1.65152	1.36364	1.58000	1.24615	1.36111	1.21429
D20	1.52174	1.42424	1.63218	1.39285	1.34375	1.31250
D21	1.71428	1.29412	1.62500	1.38182	1.35135	1.21053
D22	1.48571	1.65854	1.56701	1.59016	1.26471	1.00000
D23	1.50000	1.21739	1.57647	1.18518	1.35484	1.00000
D24	1.50000	1.30770	1.61905	1.47222	1.27273	1.23529

A.3 Illustrations

Figure A.3.1

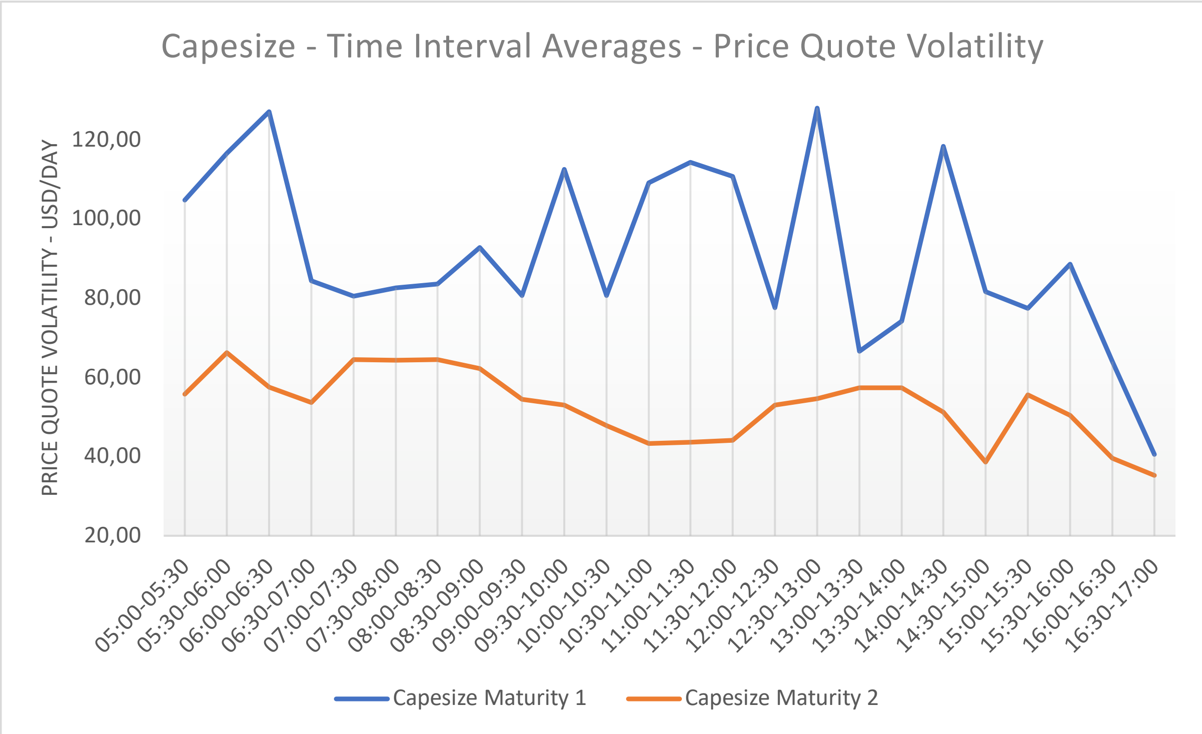


Figure A.3.2

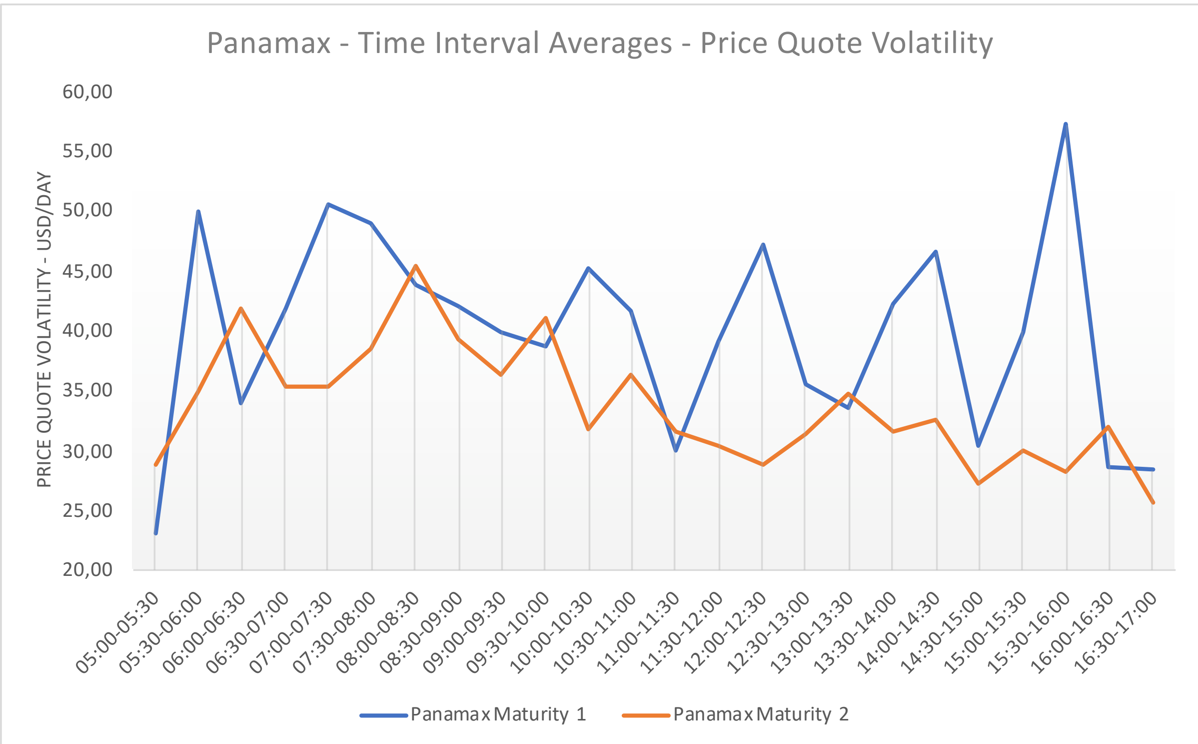


Figure A.3.3

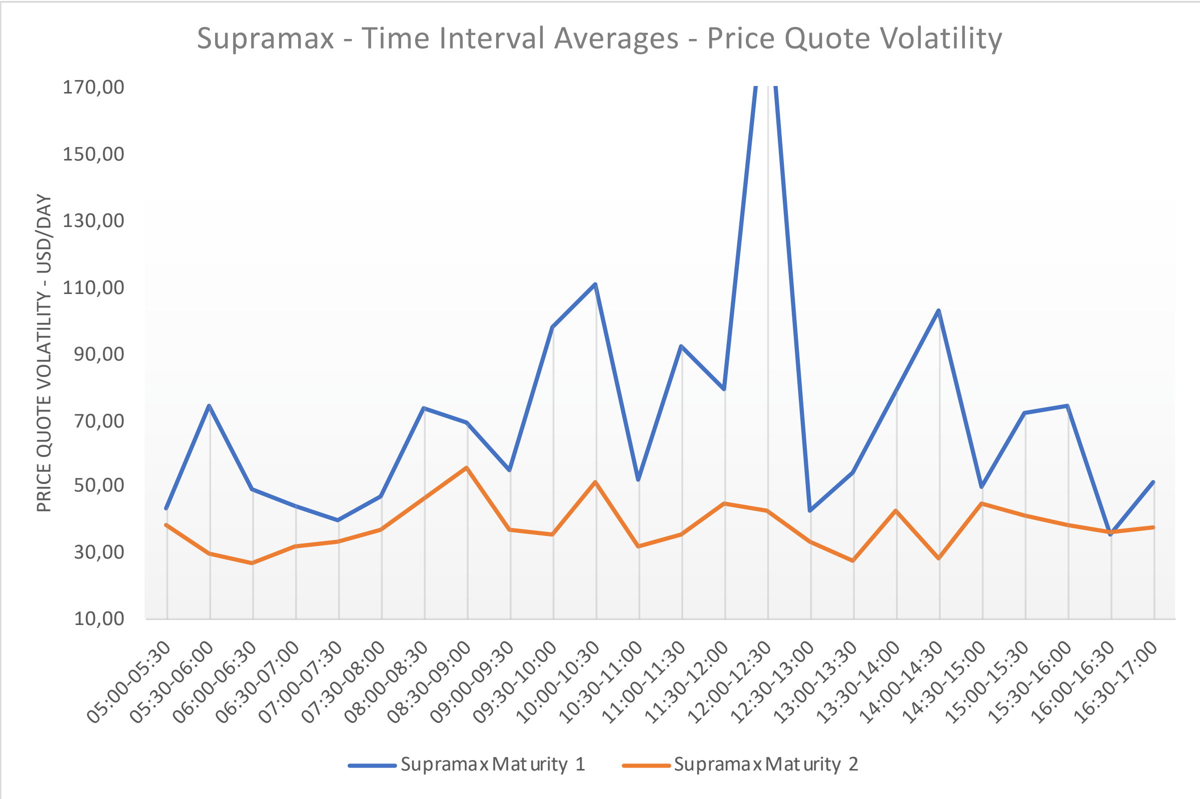


Figure A.3.4

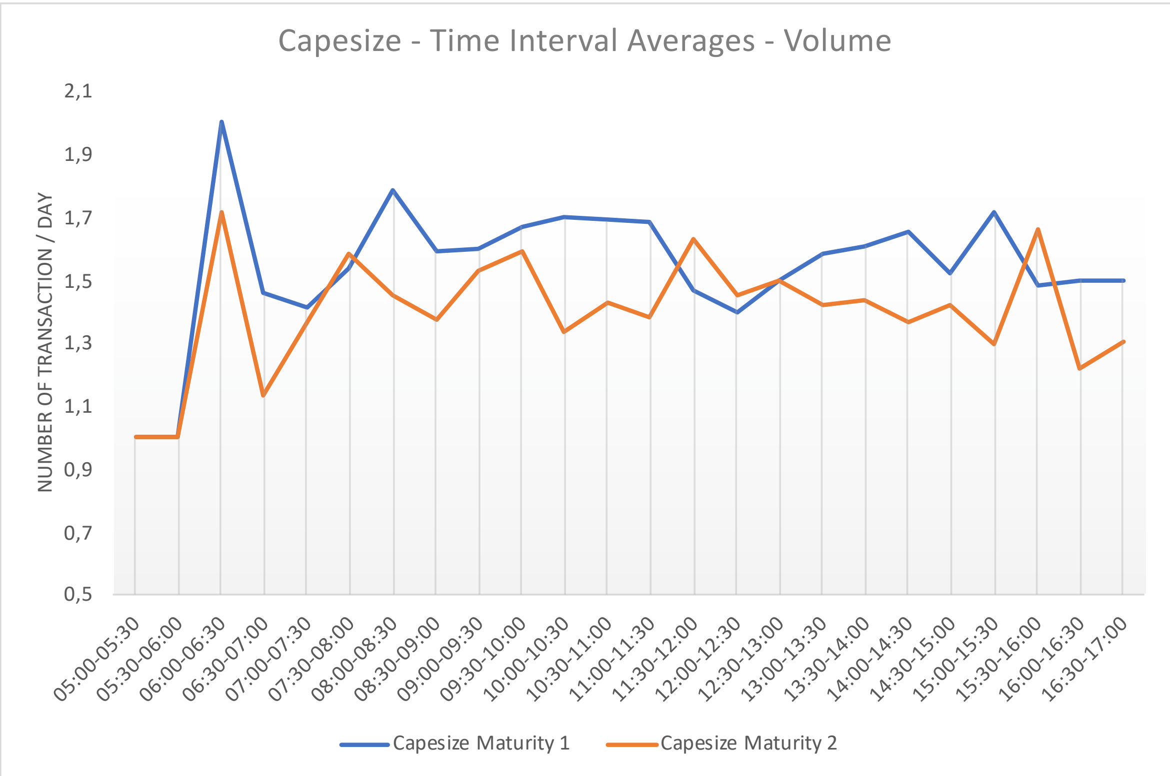


Figure A.3.5

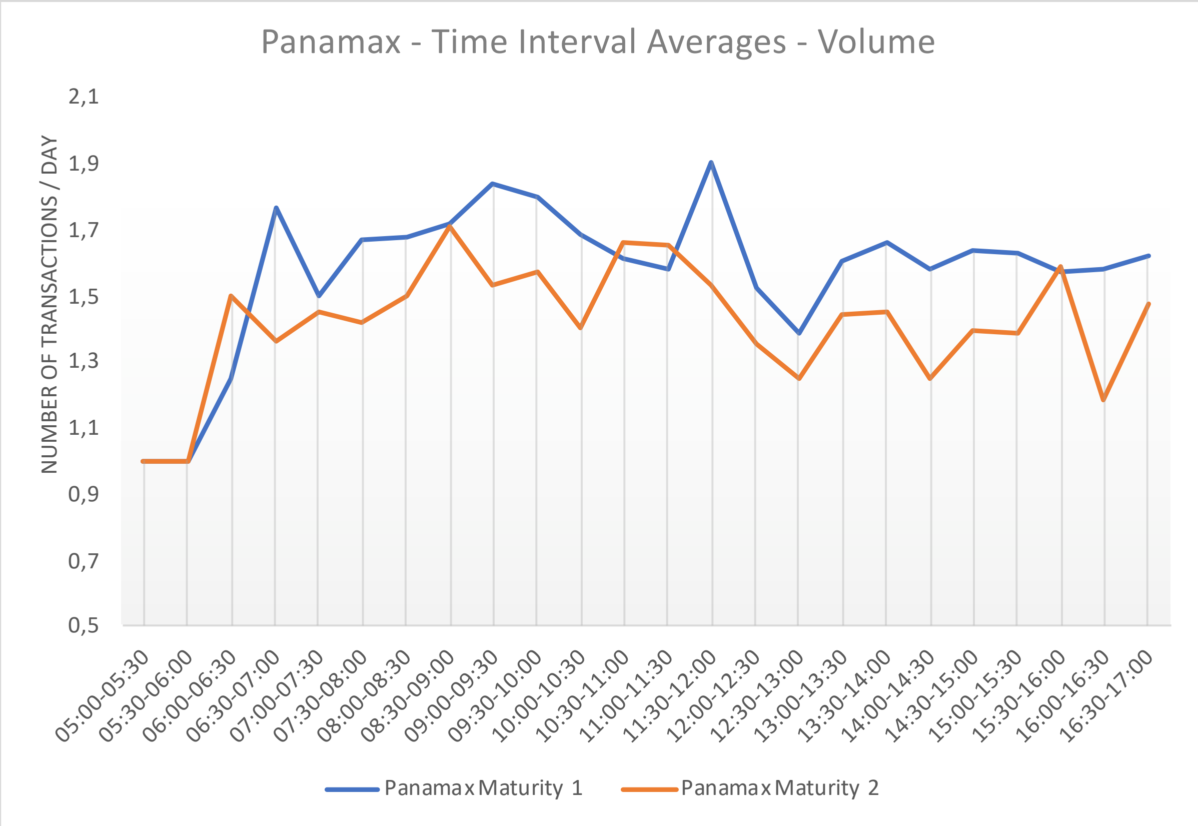


Figure A.3.6

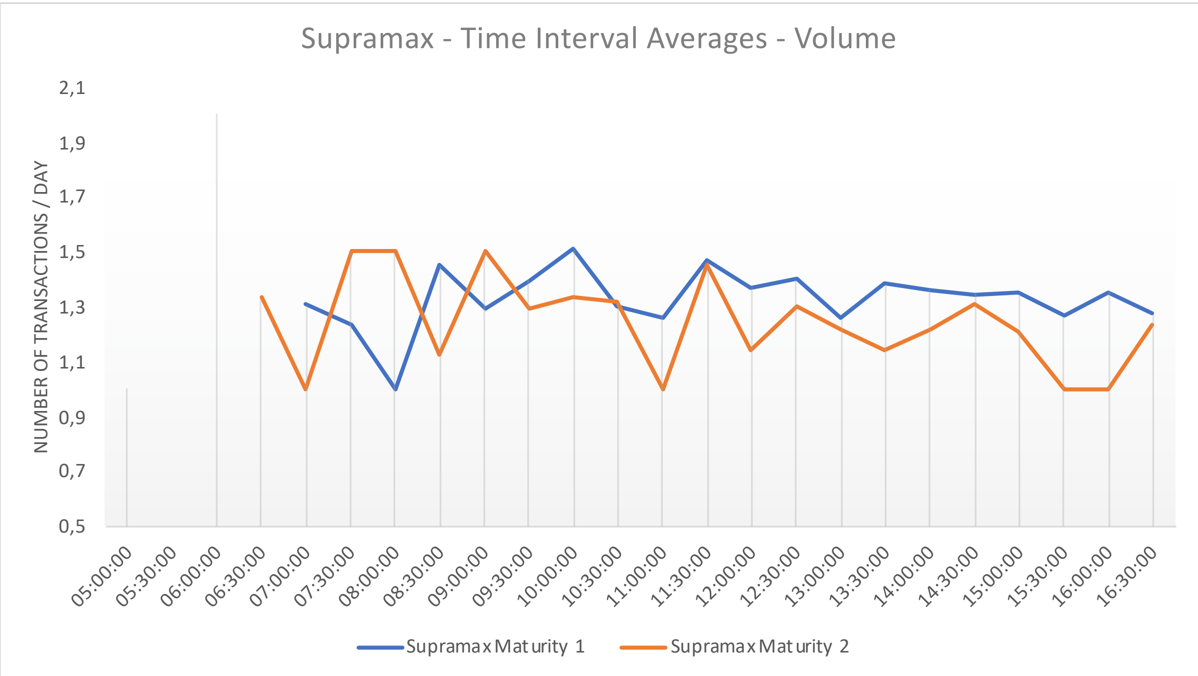
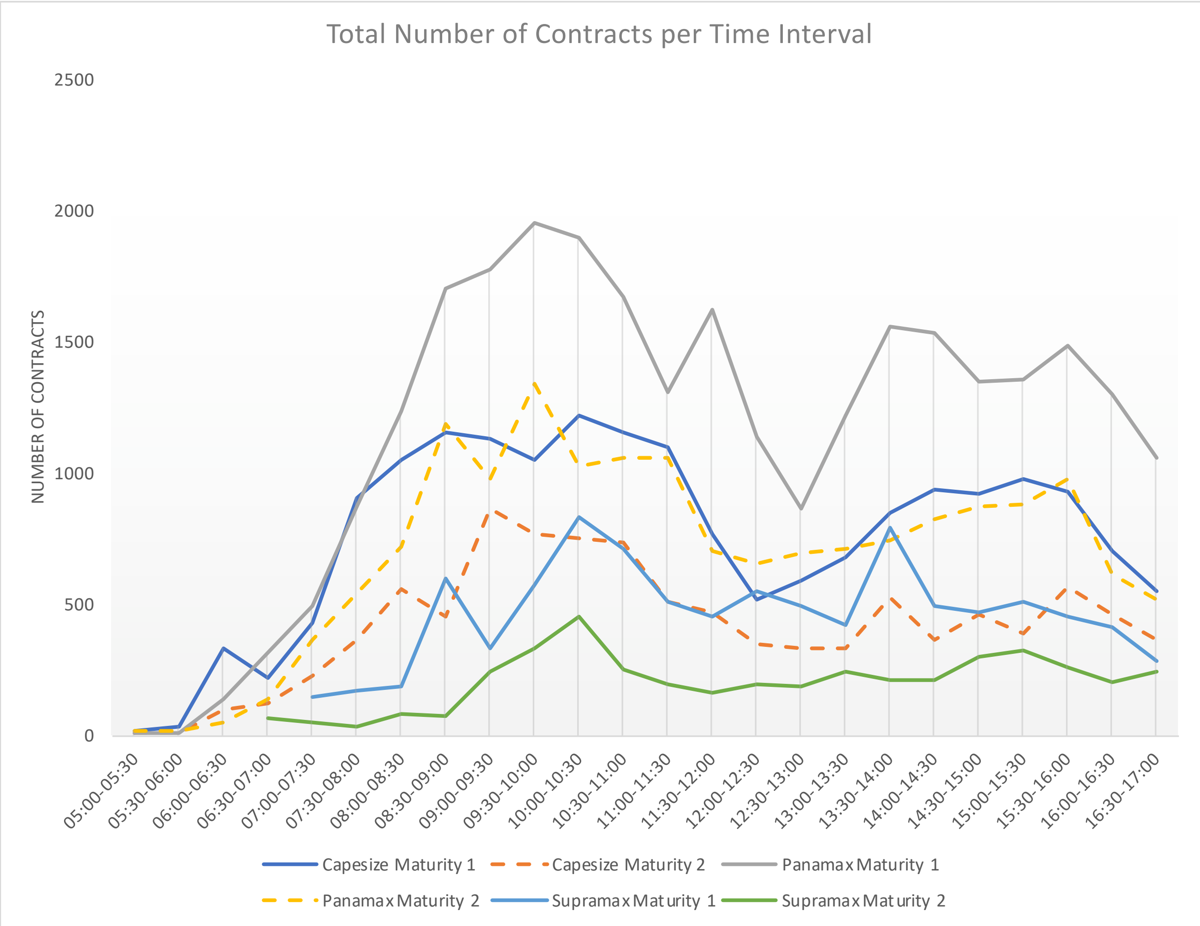


Figure A.3.7


Total Number of Contracts per Time Interval
NUMBER OF CONTRACTS
2500
2000
1500
1000
500
0
05:00-05:30
05:30-06:00
06:00-06:30
06:30-07:00
07:00-07:30
07:30-08:00
08:00-08:30
08:30-09:00
09:00-09:30
09:30-10:00
10:00-10:30
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14:00-14:30
14:30-15:00
15:00-15:30
15:30-16:00
16:00-16:30
16:30-17:00
Capesize Maturity 1
Capesize Maturity 2
Panamax Maturity 1
Panamax Maturity 2
Supramax Maturity 1
Supramax Maturity 2

A.4 Regression results

A.4.1

OLS estimates of Bid-Ask spread between London & Singapore (London indicated by D1)

	Capesize		Panamax		Supramax	
	M1	M2	M1	M2	M1	M2
D1						
β	-0.0031821	-0.0030790	-0.0018503	-0.0012996	-0.0007407	-0.0007590
	(0.0002820)	(0.0002270)	(0.0001925)	(0.0002050)	(0.0003063)	(0.0003218)
	[-11.29]***	[-13.57]***	[-9.611]***	[-6.34]***	[-2.419]**	[-2.359]**
Intercept						
β	0.0250197	0.0224523	0.0179221	0.0182674	0.0222169	0.228684
	(0.0001949)	(0.0001586)	(0.0001325)	(0.0001427)	(0.0002039)	(0.0002127)
	[128.39]***	[141.57]***	[135.28]***	[128.06]***	[108.98]***	[107.50]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5% and 1% level.

A.4.2

OLS estimates for Bid-Ask Spread vs. Volatility (Volatility indicated by D1)

	Capesize		Panamax		Supramax	
	M1	M2	M1	M2	M1	M2
D1						
β	-0.0000022	0.0000042	0.0000036	0.0000219	0.0000063	0.0000239
	(0.0000017)	(0.0000018)	(0.0000017)	(0.0000030)	(0.0000023)	(0.0000052)
	[-1.469]	[1.497]	[2.153]**	[8.452]***	[2.758]***	[4.587]***
Intercept						
β	0.02385	0.02126	0.01648	0.01550	0.02097	0.02044
	(0.0005277)	(0.0005108)	(0.0003282)	(0.0003234)	(0.0004232)	(0.0005035)
	[45.197]***	[41.626]***	[50.226]***	[47.937]***	[49.553]***	[40.592]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5% and 1% level.

A.4.3

OLS estimates of Volatility between London & Singapore (London indicated by D1)

		Capesize		Panamax		Supramax	
		M1	M2	M1	M2	M1	M2
D1							
	β	-4.259	-8.504	-4.257	-6.9206	18.29	-0.1053
		(11.282)	(2.346)	(3.334)	(1.4772)	(14.14)	(2.7715)
		[-0.378]	[-3.625]***	[-1.277]	[-4.685]***	[1.294]	[-0.038]
Intercept							
	β	94.088	57.220	42.747	37.5603	63.64	37.5511
		(7.467)	(1.549)	(2.197)	(0.9668)	(9.27)	(1.8169)
		[12.600]***	[36.935]***	[19.456]***	[38.852]***	[6.866]***	[20.668]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5% and 1% level.

A.4.4

OLS estimates of Volume between London & Singapore (London indicated by D1)

		Capesize		Panamax		Supramax	
		M1	M2	M1	M2	M1	M2
D1							
	β	-0.07370	-0.02764	-0.09389	-0.12043	-0.01342	-0.15659
		(0.05563)	(0.06077)	(0.05174)	(0.05125)	(0.05796)	(0.06866)
		[-1.325]	[-0.455]	[-1.815]*	[-2.35]**	[-0.232]	[-2.281]**
Intercept							
	β	1.63359	1.45025	1.70053	1.53015	1.35586	1.32692
		(0.03989)	(0.04311)	(0.03908)	(0.03897)	(0.04655)	(0.05477)
		[40.953]***	[33.643]***	[43.510]***	[39.270]***	[29.130]***	[24.227]***

Standard errors are illustrated in (), while t-statistics are in [].
*, **, *** Denotes significance level at 10%, 5% and 1% level.

A.4.5

OLS estimates of Trading Activity between London & Singapore (London indicated by D1)

		Capesize		Panamax		Supramax	
		M1	M2	M1	M2	M1	M2
D1							
	β	-0.41990	-0.08168	-0.59660	-0.14630	-0.02139	-0.00210
		(0.1452)	(0.04529)	(0.16000)	(0.0443)	(0.06945)	(0.03859)
		[-2.892]***	[-1.803]*	[-3.728]***	[-3.293]***	[-0.308]	[-0.054]
Intercept							
	β	5.01010	2.72970	5.25710	2.76518	2.61538	2.27661
		(0.0996)	(0.03139)	(0.10970)	(0.03060)	(0.04665)	(0.02584)
		[50.301]***	[86.968]***	[47.908]***	[90.356]***	[56.063]***	[88.112]***

Standard errors are illustrated in (), while t-statistics are in [].

*, **, *** Denotes significance level at 10%, 5% and 1% level.