Price Indices for Ocean Charter Contracts

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Abstract

There is a long history of modeling of prices of commodity transportation by sea. These prices are referred to as (ocean) freight rates. Early contributions go back to the work of Tinbergen and Koopmans in the 1930s. The shipping industry is characterized by an abundance of individual contract data, which is collected and published by so-called charter brokers. The industry publishes this data both in raw form, as monthly and even weekly average prices for selected ship sizes and commodities on selected routes, and in the form of unit value indices.

In this paper, we explore the calculation of these indices using a data set of ocean charter contracts for 1997-2005. We present unit value indices, which we compare with well known industry indices. We then explore the impact of weighting the subindices for aggregation, present indices based on matched models from period to period and we calculate indices are corrected for quality differences. Finally, we estimate price indices in which the duration of the contracts is reflected.

We find that our unit value indices show substantial differences from current industry indices. Weighted aggregation is relevant especially for dry bulk spot rates, where some size classes dominate the others. The matched model results show that matching the indices by route can lead to widely different results compared to the unit value indices. We take this as an indication that care should be taken with indices based on a set of selected 'large' routes only. The hedonic analysis shows that there are no structural quality aspects (such as age of the ship) that influence the level of the price indices. Quality differences do exist, but they are temporary, which is in line with previous research. Finally, the inclusion of contract duration is especially relevant for time charter indices, although there is also some impact for tanker spot rates. We conclude that current industry indices provide only limited insight in market developments, and we question the validity of some of the scientific research that uses these indices in its analysis.

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1 Introduction

The shipping industry is characterized by high uncertainty, combined with highly valuable assets. A new ship can easily cost over $ 100 mln, while freight rates and secondhand ship values can double or triple within a single year. Operating in such an environment requires much information on current developments. As a result, an abundance of market information is available from commercial sources. These sources are mostly ship brokers who collect data about chartering and about secondhand sale and purchase as part of their middlemen activities in the shipping industry. Much of this information is used to assess the state of the 'shipping cycle', a reference to the highly cyclical nature of the shipping industry; see for instance Stopford (1997).

The published information about freight rates is derived from so-called fixtures, i.e. short descriptions of the transaction that was fixed between charterer and shipowner. This fixture data is processed by brokers or other publishing agents into average freight rates, price indices and other market indicators, such as the number of fixtures in certain trades or periods. This information finds its way into industry periodicals such as Lloyd's List, Fairplay Magazine, Lloyd's Shipping Economist, and others, as well as into many ship brokers' periodic fax reports. For the larger part, these publications consists of freight rate information.

What remains unclear, however, to the outside observer, is how this information is transformed into economic indicators such as price indices. There is very little consensus on what type of information is required by practitioners, and what kind of decisions they base on that information. Furthermore, the methods of calculating the indices are known only superficially. Finally, in many indices, it is unclear how varying numbers of fixtures over time and missing data are dealt with. As a result, the relationship between the available data set on market transactions (i.e. the fixtures) and the economic indicators is a black box.

This paper aims at investigating the way price indices can be calculated based only on the set of available fixtures. We calculate indices in a formal, reproducible way, and suggest and compare different approaches for calculating indices. We also compare these indices with well known indices available in the shipping industry.

The comparison of the various indices will lead to new insights into the representation of market developments in shipping. A descriptive analysis of the fixtures will provides some understanding of the development of the number of fixtures over time, and the counts of fixtures by various attributes of the fixture such as ship type, contract type and route. Using these fixtures as the basis for our index calculations, we look for differences between indices based on unit values, matched models and hedonic models. Such a comparison has never been made in the shipping industry. We also introduce the calculation of indices that take contract duration into account and compare these with our other indices. These types of indices may be frequently applied elsewhere (see, on the application of duration indices, for instance, Diewert (2003)), but this is new in the shipping industry. This analysis gives us new requirements for index calculation in the shipping industry that are not met by the set of market indices that is currently available.

The paper is structured as follows. We first review the previous efforts on index construction in the shipping industry. We then present an overview of the available information in shipping and their sources. We continue with the analysis of the data and then present our weighted unit value indices and explore the impact of weighted aggregation. We then present the results for matched model indices, hedonic models, and duration indices. We finish with some concluding remarks.

2 Literature review on freight rate index construction

The maritime historic literature provides various studies of the measurement and development of prices of sea transportation. The purpose of much of this work was to make inference about productivity changes in shipping due to the introduction of the steam turbine, and the fossil fuel engine, during the late nineteenth century. Among the first to address the construction of a freight rate index is Isserlis (1938) who presents an index based on inbound and outbound trade of the United Kingdom. Subsequently, North (1958) presents several freight rate indices for the period 1790 to 1913. Harley (1988) continues and improves on some of the work of North with new historical indices for the United Kingdom. Yasuba (1978) presents work similar to Isserlis, North and Harley for Japan. More recently, Shah Mohammed and Williamson (2003) recalculate indices from the same basic material of the previous authors and extended their index to the 1960s. Below, we shall highlight some of the main issues raised in these studies.

Isserlis (1938, p. 74ff) presents a market index of freight rates based on freight contracts from 1869 onwards. In his 1938 study, he describes a reconstruction of the UK Chamber of Shipping index that he himself proposed in 1920. For this original index, he used minimum and maximum quoted freight rates on around 300 routes to and from the UK, as reported by E.A.V. Angier in the Fairplay Magazine. Isserlis observes that over the seventy year period, 1869-1936, the set of routes with price quotes changed considerably, but also that the changes in the set of routes from year to year were only slight.

He therefore adopts a chained approach, comparing rates on equal sets of routes from one year to another.

After a regulatory change in the UK in 1935, Isserlis obtained access to exact voyage descriptions on a large number of routes to and from the UK (Isserlis, 1938, p. 79). This information allowed him to use the exact price information (instead of the minimum and maximum freight rates on routes), but also provided him volume information, at least for the year 1935. He was thus able to present a weighted index of freight rates, where the weights are based on cargo volume. Due to a lack of volume data on subsequent or previous years, Isserlis employs a Laspeyres-like index formula (rather than a Fisher-like index), weighting by total revenue of trades grouped by commodity type (rather than grouped by route). In this way, he obtains a monthly freight rate index for the year 1937 and yearly index values for the years 1929, 1935 and 1936.

The work of Isserlis (1938) was criticized by Yasuba (1978) and later by Shah Mohammed and Williamson (2003). Yasuba (1978) claims that Isserlis' index is flawed because of the selection process of routes included in the reports that Isserlis uses. These reports over-represent larger, existing routes, while they under-represent newer, smaller routes. This allegedly leads to an upward bias, because newer routes, according to Yasuba, tend to start with high rates that decline as the route matures. This criticism is, however, specific for the period studied by Isserlis and Yasuba, 1789-1935, with the new shipping routes being introduced continuously by operators who could, at least for some time, act as monopolists on these routes. Also, this criticism does apply to the original index Isserlis constructed in 1920, but not to his later index, for which he used complete route information. Yasuba's criticism resembles the discussion on constructing price indices for consumer durables, where new products with initially high prices and fast depreciation may not be included in the index from the start, resulting in an upward bias of the CPI (cf. e.g. Balk, 1999; Boskin et al., 1998; Hausman, 1999, 2003). For shipping, this criticism does not hold in general, because freight rates on the newer routes with lesser supply of capacity may actually be lower, due to lack of regular cargo offerings, and the lack of back hauls.

Shah Mohammed and Williamson (2003) set out to recalculate and extend Isserlis' index, using the original material. This allows them to perform a more detailed analysis of especially total factor productivity growth. They criticize what is essentially Isserlis' chained index calculation method based on midrange prices. They argue that this method, when using a small set of underlying data, creates an upward bias in the index, which replicates over the years. This is a phenomenon that is also observed in index calculations based on scanner data, see for instance (Feenstra and Shapiro, 2003). It is induced by the movement of the underlying data, however, and not by the method of chained index calculation, as Shah Mohammed and Williamson (2003) state.

Finally, Klovland (2002, p. 6ff) criticizes Isserlis' index because the choice of routes is biased towards coal transportation, and because the long distance Europe-Asia routes are over-represented (op cit, p. 7). A similar criticism was voiced by Harley (1988) on the American indices calculation by North (1958), where cotton shipments were over-represented. This over-representation is obviously the result of the economic structure of the UK and American economies at the time, but also of the fact that a trade that results in many fixtures is more easy to pick up by reporting agencies than small routes with occasional fixtures (cf. Yasuba's criticism). In case these small routes were observed, this problem would be solved with weighting.

There are two weak points in Isserlis' approach which have not been developed much in the literature. They are in fact both mentioned by Isserlis (1938) himself. The first is his choice of using the midrange (the average of minimum and maximum) of the freight rates as an estimate of the average freight rate on a route in a certain period. He notes the drawback (Isserlis, 1938, p. 74), but argues that, on the whole, the result will be the same as when a common unweighted average was taken. He does not provide any further verification of this claim, however. The second problem is the timing of the fixtures. Fixtures have starting and ending dates of the contract, and a reporting date. Often the starting dates are inaccurate, or missing, or unreported in trade publications. This means that the reporting date is taken as the date of the economic transaction. The result is a certain mismatch between Isserlis' average freight rate data as reported in the industry press, and his volume information as he obtained from official government statistics (Isserlis, 1938, 87-88).

Isserlis (1938) also points out several interesting issues when making an index of freight rates. He argues that there is no real difference between an index of consumer prices and an index of freight (Isserlis, 1938, p. 86), although he ignores the duration of contracts. However, there are major problems related to the classification of services in shipping. A classification in ship types, or by route is possible, but neither precludes overlaps due to the same ships carrying different cargo types, or operating on various routes in sequence. A similar problem existed in Isserlis' days with the distinction between liner and tramp shipping. Nowadays, the problem has largely disappeared due to the introduction of container shipping. But it still occurs with respect to spot and time charter contracts, where the same ship can be engaged in a spot contract one time and in a time charter contract at another time. Isserlis finally settled for a classification based on ship type and route combinations (Isserlis, 1938, p. 59ff).

Later attempts at constructing and improving freight rate measurement in shipping are made by North (1958) and Harley (1988). North (1958) reports on a study initiated at the National Bureau of Economic Research (NBER) in the mid-1950s, that aimed to collect annual transportation cost data from 1750 to 1913, 'on every major bulk commodity on every major trade route in the world' (North, 1958, p. 537). This resulted in a set of indices to and from major economic areas in the world, such as the UK, the European continent and the United States of America. North (1958) does not report details of the index construction method, but more details can be found in North (1960). Nevertheless, his approach seems to be similar to Isserlis' approach of averaging rates over several routes, with weights based on transported volumes. Harley (1988) criticizes North's approach because he feels the American cotton trades are over-represented. Harley (1989) constructs new series for exports out of Britain, which are an innovation in the sense that they contain new routes based on new data that Harley specially collected in secondary shipping centers in the UK (most notably Newcastle). The indices themselves are weighted averages of freight rates with the volumes of 1910-1913.

These attempts all reveal that there is a longstanding interest in maritime freight rate index calculation, both from a balance of payments point of view (Isserlis, the UK Chamber of Shipping, North), from a productivity analysis point of view (Harley, Yasuba, Shah Mohammed & Williamson), as well as from an academic point of view of finding a reliable method of index calculation. This type of investigation has not been conducted for the current period, however.

3 Maritime market information

The marine transportation industry is marked by a wealth of published indicators about various aspects of seaborne trade. The purpose of this section is to provide a discussion of the market insights desired by the industry, and to give an overview of the different uses of this information, the various parties involved in the processing of data and publishing of indicators, and the underlying sources of data and their link with actual operations.

3.1 Industry market insight

The shipping industry is a capital intensive industry characterized by great uncertainty. Part of this uncertainty is the result of the mobility of the ship, the fragmentation of the market on both the demand and the supply side, and the relationship with other volatile markets such as the oil market. Many practitioners, both charterers and shipowners, therefore rely on various types of market information for their decision making. The ’default information package’ usually covers the supply of capacity (orderbook information, ship deliveries, scrapping of ships), the demand (seaborne trade carried in previous periods, growth of seaborne trade), and prices of charter contracts and ships.

The main interest of the shipowner is his daily earnings, which are fixed if there is a contract, but depend on the balance between demand and supply if his ship is open for chartering. As a result, the shipowner is interested in current prices for contracts for cargoes, routes, ships comparable to his own business, as well as developments of the main cost item, which is fuel. Therefore, we would expect the shipowner to be mainly interested in a price index based on contracted prices in a certain period.

Charterer do not have entirely the same interest. They are responsible for moving certain volumes of cargo per period, against reasonable prices. Prices may fluctuate, but what matters is the surplus of average sales prices for the commodity and average transportation costs for the total volume of cargo, for a given period. Therefore, charterers would be more interested in a transportation cost index, which includes prices of all existing (running and new) contracts.

There are other parties who are also interested in charter price developments. Banks, for example, often base their lending decisions on the probable development charter prices for several future years. An important input for such predictions is the current level of time charter rates. Also, international economists are interested in freight cost indices for balance of payments and other purposes. Many international trade models include transport cost indicators, of which international shipping costs is very representative. One could argue that most of these non-shipowning or chartering parties are mostly interested in indices that also reflect the duration of contracts.

3.2 Data collection and marketing

The maritime industry has a fairly accessible source of raw data about transportation contracts. These so-called fixtures specify the name of the ship, cargo information, route, special contract conditions, and the agreed price. In addition, fixtures state timing information: the date when the deal was reported, and starting and ending dates, or, for time charter contracts, the duration of the contract. Below, we describe the information demand and supply in the shipping industry and subsequently discuss various freight rates indices published by industry parties.

The information moved around in the shipping industry basically comes from two sources: the transactions in the charter market (and the customs declarations associated with the movement of the cargo) and the investment decisions in the ship market. Figure 1 illustrates how the data from these sources find there way into usage through various stages of data collection, marketing, and information product development. These stages are briefly discussed below.

Transactions There are four main markets in shipping (see Beenstock and Vergottis, 1993; Veenstra, 1999): charter market, new building market, secondhand ship markets and ship scrapping market. The charter market has many segments, and only some of these (voyage charters, shorter time charters) are observed. Voyage charter markets are markets for so-called spot or voyage charter contracts that cover a single trip of the ship from port A to port B. The price for this contract is quoted in dollar/ton, and the shipowner pays for all ship and voyage related costs, especially fuel. In time charter markets contracts are fixed for a specific period of time, and prices are quoted in dollar/day. Under time charter contracts, the charterer is responsible for fuel costs, but warranted speed and fuel consumption are fixed in the contract. Moreover, irregularly observed contract types are: very long time charter contracts (up to 15 years duration), so-called bareboat charter contracts (which exclude crewing in addition to fuel costs);

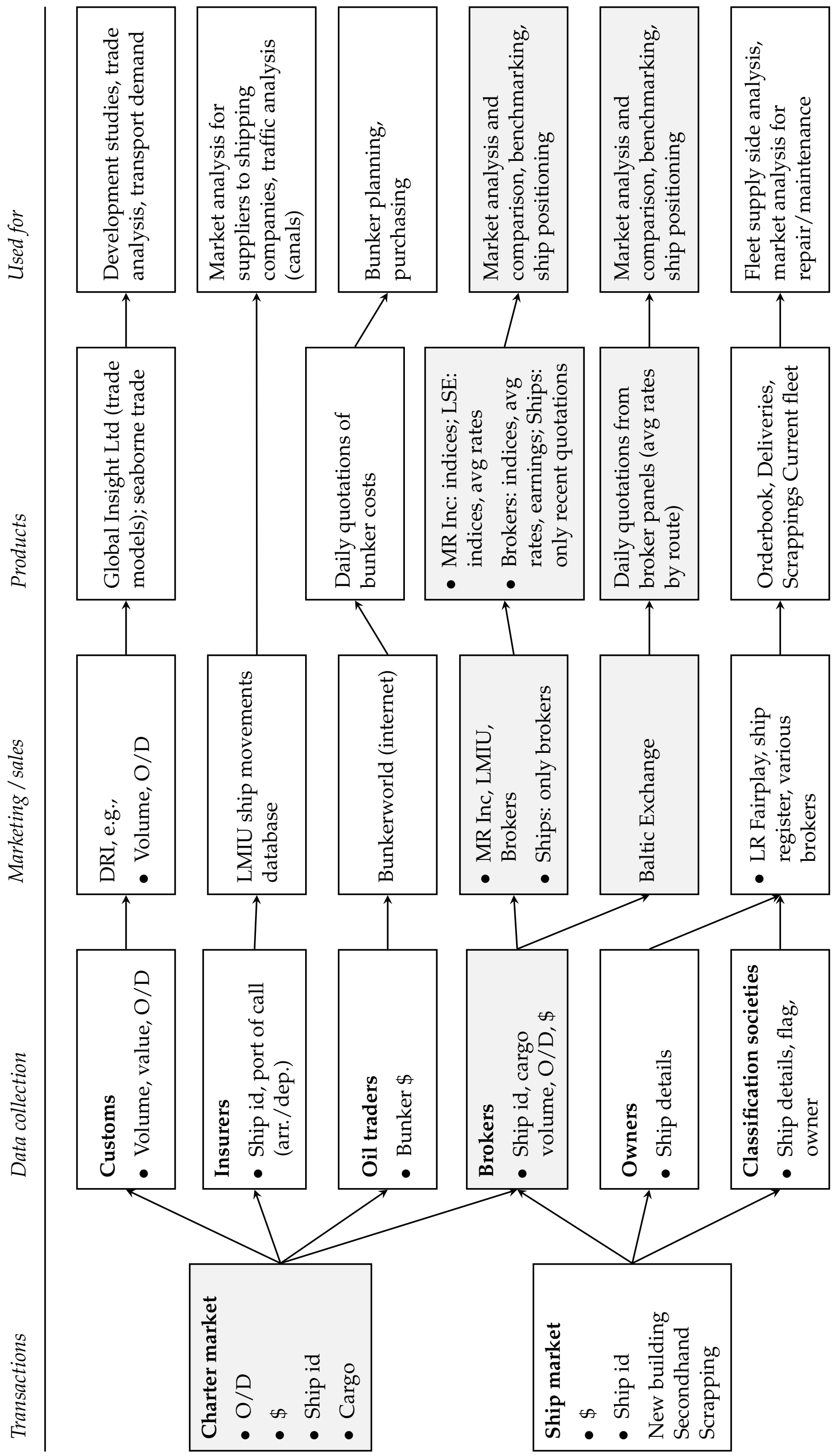


Figure 1: A model of information flows in the Maritime Industry

contracts of affreightment, for specific cargo volumes that may be carried by more than one ship; and charter contracts for uncommon or special cargoes, such as refrigerated products, cars, LPG and LNG gas, life stock, heavy objects, project cargo and so on.

Data collection Customs of all countries collect data on import and export. Collection is in volume and value, but value data is more important for customs. Reported data may include cost items, depending on the dominant terms of trade, such as CIF or FOB. Insurers and associated bodies (for instance the London Underwriters Association) collect data through agents in 2500 ports or so. They record arrival date and departure date of ships in ports and major canals and waterways. Brokers collect data on the deals they are involved in. Major brokers (Clarkson, Simpson Spence & Young (SSY), Braemar Seascope) cover a substantial part of the market in their own specific segments, but coverage is never complete. Classification societies, such as Lloyd's Register, American Bureau of Shipping, collect data about ships they classify, and determine the exact ship type and various size measurements (gross tonnes, net tonnes, deadweight tonnes, net water displacement tonnes). All ship data is also collected by one central organization, LR Fairplay. Their register of ships is the definite one, at least in terms of technical specifications.

Marketing and selling Some of the organizations sell the data they collect in raw form (Day Robinson International (DRI), Lloyd's Marine Intelligence Unit (LMIU), brokers) or after simple data processing (selection, addition, averaging). The raw data is often fraught with errors, due to typing mistakes, missing data, etc. LMIU obtains data from most of the larger brokers, and so does Marine Research Inc (MRI). LR Fairplay obtains the ship data because they give out the IMO number, which is the world's unique ship identifier. Once the ship is in the LR Fairplay register, however, the classification society and brokers are often better informed about the ship details. Average quotations of prices per ship type, size class, commodity and route are available to members of the Baltic Exchange.

Products The distinction between marketing and products may be a bit forced. However, apart from the data being sold in raw form, much of it is packaged with front end software or through service contracts. For instance, the consultant company Global Insight, builds models using the DRI data. Lloyd's Shipping Economist (LSE) who has the same owner as LMIU, uses LMIU data to calculate indices and other indicators on freight rates and also reports the ship movements in the monthly magazine. LR Fairplay has a range of database products to package the data (PC Register, etc) and so has Clarkson Research Studies (subsidiary of Clarkson Ship Brokers), see the Shipping Intelligence Network on internet. The Baltic Exchange maintains a large number of broker panels who are called for a daily quote of freight rates on all kinds of routes. These quotes are combined into daily indices for different ship types and routes. Many brokers sell information products such as daily, weekly, monthly, and yearly fax sheets and reports. A number of brokers and the Baltic Exchange calculate proprietary indices (SSY Capesize indices, JE Hyde Handy Indices, Baltic Exchange Freight Indices).

Usage The more interesting insights into the shipping industry are obtained from a combination of sources: merging fleet data with trade data (to analyse ship utilization and transport patterns), or freight rate data with ship sailing data (to investigate geographical market segmentation (Laulajainen, 2006), or the combination of supply, demand and pricing data in industry models. The charter information results in various published freight rate indices that will be discussed in the next section.

3.3 Various published freight rate indices

Based on the fixtures data, the industry reports three types of price series: average freight rates (for dry bulk carriers in $/ton or $/day, and for tankers in worldscale, a reference system that quotes price as a percentage of a standard rate for an average ship); route-based freight rate indices; and aggregate freight rate indices. The route-based indices are unit value indices representing unweighted average freight rates for selected routes. The aggregate indices include all available fixtures, or a fixed selection of routes, and are still based on unit value calculations, but normalized against a fixed base year.

The main industry indices are: Lloyd's Shipping Economist tramp trip charter index (LSE TTC) (Informa Maritime & Transport, 1978 - current); Maritime Research Inc. freight indices (Maritime Research Inc., 1970 - current); Baltic exchange dry bulk indices and various sub-indices (Baltic Exchange, 1985 - current); SSY Capesize indices, Atlantic and Pacific (SSY, 1985 - current); JE Hyde handy indices, supermax and handymax (Icap Hyde, 1990 - current). The Lloyd's index is constructed from five sub-indices for different ship size classes. The sub-indices are constructed as unit value indices, while the aggregate index is a weighted average of these sub-indices. The weights have been determined several years ago, and represent the capacity distribution of ships in size classes at that time. The Maritime Research general freight index has two sub-indices based on commodity type (one for grain transports, and one for other cargo types). These two sub-indices are based on fixtures for selected major trade routes. Maritime Research also reports three time charter indices for different durations of the contract. The Baltic Exchange indices are not based directly on actual fixture information, but on daily brokers' assessments of freight rates on a great number of routes. Assessments of different brokers are averaged to obtain quotations for a route.

The SSY and JE Hyde indices are constructed from average price quotes on around ten selected routes. These averages are then aggregated according to a weighting system that reflects the 'importance' of the routes. Routes with more cargo, fixtures, and/or ships obtain a higher weight. SSY decided some time ago that this weighting did not have any significant impact on the pattern of the index. Therefore they base the index on an unweighted average of the average prices per route. Also, see Glen and Rogers (1997), who reach the same conclusion from an assessment of the level of co-integration between the route-based sub-indices.

Data providers make different choices to segment the market. For instance, the Lloyd's Shipping Economist's index segments by size class, while the Maritime Research index segments by commodity type. The segmentation by size class is more in accordance with international shipping practice. We therefore prefer the LSE indices as a benchmark to our indices, as compared to the MRI indices.

3.4 Problems with freight rate indices and the underlying data

The existing freight rate series published in the shipping industry suffer a from number of problems and shortcomings.

First, the basic data source, the fixtures, may not be complete. Upon inquiry, industry experts state that the publicly available fixtures may cover about 70% of the market, with a bias towards spot and relatively short time charter contracts. The longer time charter contracts (longer than 2 years) are often not reported in the maritime press. At the same time, however, Laulajainen (2006) claims that industry experts generally think that the fixture set is a good representation of market developments.

Second, the reported content of the fixtures may be based on guesses, hearsay and incorrect data. Fixtures may not even represent real contracts, but just intermediary deals, that are done purely for speculative reasons (Laulajainen, 2006).

Third, the number of fixtures per period strongly fluctuates over time. This may not be problematic for aggregated freight rate series, but it is for the commonly reported prices for the triplets: ship size, cargo type and route. Many of these triplets show very little and irregular contracting activity. This can even be the case for common routes, such as Capesize shipments from from Australia to Japan or Panamax shipments of grain from the US Gulf to Japan or Europe, where there may not be fixtures for several consecutive months. The industry's solution is to fill in the information gaps with estimates obtained from industry experts, such as the London Tanker Broker Panel (www.ltbp.co.uk) or the Baltic Exchange Broker Panels (www.balticexchange.com). Some indices, such as the Baltic Exchange indices, are reported on a daily basis, and therefore have to rely almost completely on industry panels. Their weekly and monthly series are time aggregates of these 'industry expert rate series'. The development of fixtures counts over time is further analyzed in the next section.

Fourth, while the basic data contains information about volume (amount of cargo moved), this information is not used in some of the formal indices or the average freight rate indicators.

Fifth, the shipping transactions are not buy and sell transactions, but rather services, that have a certain duration. As a result, an index based on contracted transactions will only represent price movement, but not the overall price level in the industry. Basing decisions on the contracting price movements alone may result in seemingly myopic behavior, something the industry is constantly accused of (e.g., Stopford, 1997).

Sixth, the fluctuating volume of fixtures over time also implies that freight rate averages are sometimes calculated over very few fixtures. These thin averages appear in a time series with other averages in which much more fixtures were included. A simple experiment with a random generator shows that this may introduce some degree of time varying volatility into the freight rate series.

Notwithstanding these shortcomings, many academic studies have been using average route-based contracted freight rate series, and some of the formal indices in modeling exercises for quite advanced analysis. They find evidence of serious time varying volatility (Kavussanos, 1996, for an early reference), non-linearity (Adland and Cullinane, 2006), conflicting evidence of stationarity and non-stationarity of series (Koekebakker et al., 2006), unexpected relationships between trading volume and price (Syriopoulos and Roumpis, 2006), a strong relation between ordering new ships and short term spot rate developments (Veenstra, 1999) and so on. We conjecture that some of these results may be due, at least in part, to the poor quality of the underlying data, instead of the sometimes peculiar economics of the shipping industry. We leave the verification of this conjecture for another paper.

4 Data analysis

In view of the empirical analysis, this section describes the data source used, discusses the processing of the data and provides an initial overview of the development of the number of fixtures over time. The latter illustrates the issue of thin trading raised in the previous section, but also provides a reference for understanding some of the methodological choices and analysis results of subsequent sections.

4.1 Data source

The main data source available has been obtained from Maritime Research Inc (MRI) in Washington DC (USA), which has been collecting this information since 1953. For publication purposes, they have an agreement with LR Fairplay. Fixture data has been used by, for instance, Bates (1969), Shimojo (1979) and more recently by Tamvakis (1995), Tamvakis and Thanopoulou (2000), Adland and Cullinane (2006) and Laulajainen (2006). Some of these studies, such as Tamvakis and Thanopoulou (2000), Adland and Cullinane (2006) and Laulajainen (2006) report the use of data supplied by Drewry Shipping Consultants, Clarkson Research Studies or LMIU, respectively. There may be differences in the data sets from these various agencies, in terms of coverage of various ship types, commodities or geographic areas. In addition, we have ship details from the LR Fairplay ship register, containing various size measures, nationality of flag, country and year of build and design speed and consumption for all ships in existence in december 2005. For ships scrapped during 1997-2004, we do have fixture data, but no ship details. The two databases can be merged by means of a unique 7-digit ship identification code: the IMO-number. Due to some missing ship details as a result of scrapping, this merging results in some loss of fixture data.

The fixture data source contains information about prices of spot contracts per reporting date and prices of time charter contracts per reporting day, for both bulk carriers and tankers. Spot prices for bulk carriers are in $/ton, while time charter rates are $/day. Tanker rates are in worldscale. Some contracts, especially for tankers, are quoted in lumpsum figures. All lumpsum contracts were excluded from our data set. Other information contained in spot contracts consists of contract variables (contract price, origin, destination, cargo type, parcel size) and ship characteristics (individual identifier, various size measures, speed, and fuel consumption). Distance and contract duration can be determined from the origin and destination information, but due to missing values, this can only be done for about half of the available observations. For time charter contracts, the contract variables include duration, warranted speed and warranted consumption instead of origin, destination and cargo type.

The freight rate data requires considerable preprocessing before they can be used for analysis. Examples are the occurrence of alphanumeric characters (such as 'Mtrc', 'Ton', 'Bbl', 'Equi', 'Old', 'New', 'Net', 'Eur', 'Avg', '&', 'op', ''w', 'd' or '$', or parts or combinations thereof) in the numeric charter rate information, or the use of price ranges (for example '17-20000'). Similar experiences have been reported by Tamvakis (1995) and Tamvakis and Thanopoulou (2000). In the case of the spot contract data, a limited number of 161 fixtures with unrealistic reported freight rates below 1000 $/ton were dropped from the data set yielding a set of 115983 valid price quotes. From this, 9571 observations were skipped because of missing ship identification numbers (IMO-number) and another 4 observations with invalid identification numbers. From the remaining 106408 observations a fairly large amount of 18568 records did not have a match with the ships' database (probably because those ships were scrapped before 2005) and accordingly had to be skipped, while 6 observations had missing size data. The ship's database is relevant in this context because it contains information about the size of the ships, but more importantly, age and speed and fuel consumption. In the end, our spot fixtures data base has 87834 usable observations, 7140 for bulk carriers and 80694 for tankers, spread over the nine year period, 1997-2005. In the case of the time charter data, we have 30191 observations with positive reported contract duration left after necessary preprocessing, of which 1428 have no IMO-number and another 1738 observations could not be matched with the ships' database. The resulting data set consists of 27025 time fixtures, 1840 for tankers and 25185 for bulk carriers.

4.2 Development of the frequencies of fixtures

As a first step, we analyze the frequencies of fixtures over time by type of contract (spot or time charter), ship type (bulk carrier of tanker) and size class. The frequencies of spot fixtures in tables 1 and 2 have been determined by ship type (tanker, dry bulk carrier) and size classes. The size classes for bulk carriers are: Handysize, 0-35000 deadweight ton (dwt); Handymax, 35-55000 dwt; Panamax 55-80000 dwt; and Capesize 80000 dwt+. Those for tankers are: Parcel tanker, 0-35000 dwt; Panamax, 35-80000 dwt; Aframax, 80-110000 dwt; Suezmax, 110-160000 dwt; and very large crude carrier (Vlcc), 160000 dwt+. The counts show that tankers are strongly over-represented in the data set, with over a factor 10 more quotes than bulk carriers. The average number of quotations of tankers is around 9500-10000 per year towards 2005, while the number of fixtures per year for dry bulk carriers slowly decreases to around 500 per year. This trend is the same for all dry bulk carrier size classes, but is particularly strong for the Handymax category. The increase in tanker quotations over time is strongest in the Aframax and Vlcc classes.

Table 1: Spot fixture counts dry bulk carriers

Year	*Handysize*	*Handymax*	*Panamax*	*Capesize*	*Total*
1997	128	254	168	344	894
1998	180	219	200	420	1019
1999	172	181	168	449	970
2000	177	95	216	452	940
2001	132	96	165	483	876
2002	113	106	115	425	759
2003	77	65	95	383	620
2004	88	72	108	282	550
2005	87	37	117	271	512
total	1154	1125	1352	3509	7140

Handysize, 0-35000 dwt; Handymax, 35-55000 dwt; Panamax, 55-80000 dwt; Capesize, 80000 dwt+

For spot fixtures, the presence of seasonal effects in the development of the number of quotes per month has been examined with a simple OLS regression of the number of quotations on monthly dummies. For dry bulk carriers, the joint F-test that the dummy coefficients are all equal to zero could not be rejected (F=0.818, p=0.62). A similar result is obtained for tankers (F=1.147, p=0.33). We conclude that there is no periodic pattern in fixtures over months. As a result, we would not expect much difference between year-over-year and period-to-period indices.

The mean monthly number of spot fixtures for bulk carriers is 75 in 1997, but then decreases from 85 in 1998 to 43 in 2005. The number of quotes strongly differs between size classes, where the Capesize category captures about half of these contracts. By contrast, the monthly number of fixtures for Handysize decreases from 15 in 1998 to 7

Table 2: Spot fixture counts tankers

Year	*Parcel*	*Panamax*	*Aframax*	*Suezmax*	*Vlcc*	*total*
1997	1064	2356	1346	922	656	6344
1998	1330	2313	1494	1090	708	6935
1999	1495	2693	2049	1337	924	8498
2000	1604	2900	2460	1528	1201	9693
2001	1826	2709	2281	1400	1201	9417
2002	1960	2990	2409	1555	1201	10115
2003	1749	2549	2545	1585	1316	9744
2004	1670	2609	2653	1532	1411	9875
2005	1567	2790	2766	1546	1404	10073
total	14265	23909	20003	12495	10022	80694

Parcel, 0-35000 dwt; Panamax, 35-80000 dwt; Aframax, 80-110000 dwt; Suezmax, 110-160000 dwt; and Vlcc, 160000 dwt+

in 2005. For tankers, the monthly number of spot contracts has increased from 646 in 1997 to 940 in 2005, and a maximum of 1041 in 2003. The increases tend to be higher for the larger size classes: for Aframax the monthly quotes increase from 112 in 1997 tot 231 in 2005, for Suezmax from 77 to 129, and for Ulcc from 55 to 117.

If the current segmentation by contract, ship type and size class is further broken down by routes (origin and destination combinations for 10 areas), we find that overall only a limited number of routes have non-zero counts of fixtures for all months. In fact, for bulk carriers, only one out of the total potential number of routes of 324 has fixtures in all 108 months in our period of analysis. There are two more bulk routes (all for Capesize vessels) that have fixtures in over 100 months. Not surprisingly, these are typically the routes that are reported in the maritime press as being representative of market developments. For Capesize bulk carriers, out of 3509 quotes in our nine-year period, 744 originate from the Indonesia/Australia region, 1298 from west coast South America/West Africa, and another 800 from Middle East/South Africa. These three regions are all supply regions for bulk commodities, and they make up 81% of the quotes. For the smaller bulk size classes, there are no size class/route combinations with non-zero fixture counts in all months.

For tankers there are 21 routes out of a total of 396 routes that have a complete set of observations. Also, a similar level of regional concentration can be found, which differs however by size class. For the largest tankers, 77% of the fixtures originate from the Arabian Gulf region. For Suezmax and Aframax tankers, 96% and 66% of the fixtures relate to intra-European and Mediterranean trades (largely Russian and North African oil being carried to Europe). This particular regional structure associated with each size class probably explains why many practitioners (charters, owners, brokers) tend to specialize in one size class or another. It is an indication of a relatively high degree of homogeneity at the size class level for both tankers and dry bulk carriers. This is one important consideration in constructing overall bulk carrier and tanker indices based on an aggregation of sub-indices that reflect size class.

Time charter fixture counts have likewise been explored for segmentations by ship type (tanker, dry bulk carrier), and size class; see tables 3 and 4. Contrary to the spot fixtures counts, the results show a strong over-representation of bulk carriers compared to tankers. For dry bulk carriers, the development of the yearly number of time charter fixtures is seen to increase. Moreover, the mean of the monthly number of time charters for dry bulk almost doubles from 167 in 1997 to 329 in 2005. Again, substantial differences exist between size classes where the largest share of time charters is found for Panamax ships with an increase of 103 fixtures in 1997 to 203 in 2005. The Capesize category which is relatively popular in the spot markets also shows an increase of the average monthly number of fixtures from 25 in 1997 to 64 in 2005. A straightforward explanation for the differences between spot and time charter developments may be that the sudden increase in demand and higher freight rates for maritime transportation of dry bulk cargoes has prompted carriers and shipowners to switch from spot to period contracts in order to secure structurally higher freight rates before demand will start to decline again.

From these tables it also clear that the tanker industry relies much more on spot contracting than on time charter contracting, and that it does not follow the bulk carrier industry's shift to time chartering. The mean yearly number of time charters varies from 175 in 1997 to 129 in 2005 with a maximum in 2001. At a monthly basis, the mean number of quotes for all five size classes combined increases from 15 in 1997 to 23 in 2001, and then decreases again to 11 in 2005. The reasons for this distinct behavior require further analysis, but in any case, we interpret this as evidence for different underlying economic structures in oil and in dry bulk shipping and trade.

Table 3: Time charter fixture counts dry bulk carriers

Year	*Handysize*	*Handymax*	*Panamax*	*Capesize*	*total*
1997	164	304	1239	301	2008
1998	123	266	1242	211	1842
1999	148	373	1562	314	2397
2000	218	417	1754	375	2764
2001	225	515	1485	275	2500
2002	158	545	1867	403	2973
2003	104	488	2055	608	3255
2004	162	596	2091	655	3504
2005	110	625	2437	770	3942
total	1412	4129	15732	3912	25185

Handysize, 0-35000 dwt; Handymax, 35-55000 dwt; Panamax, 55-80000 dwt; Capesize, 80000 dwt+

For time charter fixtures, the development of the number of quotes per month was investigated by a regression on monthly dummies. For dry bulk carriers, the joint F-test that the dummy coefficients are equal to zero could again not be rejected (F=0.855,

Table 4: Time charter fixture counts tankers

Year	*Parcel*	*Panamax*	*Aframax*	*Suezmax*	*Vlcc*	*total*
1997	15	79	58	19	4	175
1998	6	83	72	16	13	190
1999	2	116	83	7	9	217
2000	6	125	70	22	17	240
2001	12	136	77	19	31	275
2002	5	140	50	22	43	260
2003	3	111	41	20	17	192
2004	1	69	47	20	25	162
2005	2	55	30	22	20	129
total	52	914	528	167	179	1840

Parcel, 0-35000 dwt; Panamax, 35-80000 dwt; Aframax, 80-110000 dwt; Suezmax, 110-160000 dwt; and Vlcc, 160000 dwt+

p=0.59), and we obtain a similar result for the tankers (F=0.506, p=0.90). Again, we do not observe a strong periodic pattern in fixtures over months.

The time charter contracts could be further segmented on the basis of duration, but we did not investigate this further. As a final element in the data analysis, we report the average duration of time charter contracts for bulk carriers and tankers.

Table 5: Average contract duration (in days)

Bulk charter			*Tanker charter*		
Size class	*Spot*	*Time*	*Size class*	*Spot*	*Time*
Handysize	17	60	Parcel	8	283
Handymax	22	74	Panamax	9	190
Panamax	19	92	Aframax	8	311
Capesize	22	136	Suezmax	12	419
			Vlcc	20	616

For bulk: Handysize, 0-35000 dwt; Handymax, 35-55000 dwt; Panamax, 55-80000 dwt; Capesize, 80000 dwt+. For tankers: Parcel, 0-35000 dwt; Panamax, 35-80000 dwt; Aframax, 80-110000 dwt; Suezmax, 110-160000 dwt; and Vlcc, 160000 dwt+

From this table, it is clear that the spot contracts are mostly short contracts that do not take more than a month on average. Time charter contracts have a much longer duration, especially for tankers, where the average duration can reach almost two years. As a result, we do expect to find a significant impact of taking duration into account in the freight rate indices for time charter contracts.

5 Unit value freight rate indices

The calculation of freight rate indices requires the notion of a product or service, and of the associated price. Although the previous analysis of the fixture counts has shown that there is an association between ship type/size class and route (and possibly cargo type), this association is certainly not perfect. The mobility of ships between regions, cargoes and contracts makes the definition of a fixed product or service difficult. However, the reporting practice in the industry could give an indication of what the industry considers a homogenous activity.

A comparison of the construction of the published freight rate indices and other statistics by the industry magazines mentioned in section 3.3 reveals that five dimensions are commonly used for segmentation of the industry: (1) ship type (dry bulk carrier or tanker); (2) ship size (various size classes, depending on ship type); (3) contract type (voyage charter or time charter); (4a) cargo type, in the case of voyage charters (for dry bulk: iron ore, coal, grain, other; and for tankers: dirty, clean, chemicals); (4b) duration, in the case of time charters; and (5) route (many possibilities).

We choose to follow this structure up to the third level of segmentation: we distinguish ship types, size classes and contract types. Following our analysis of fixture counts, the volume of fixtures at this level tends to be sufficient for meaningful economic analysis, while further segmentation makes the body of data rather thin. Furthermore, as we have mentioned above, the size class level provides groupings of fixtures that are fairly homogeneous in terms of the underlying economic structure of demand and supply. For each of this segments, we construct unit value freight rate indices, largely in line with industry practice. Below we introduce the formal notation and define the freight rate indices.

5.1 Definition of the unit value freight rate indices

For sake of exposition, we assume that transportation services can be distinguished into K elementary categories $k = 1, \ldots, K$. An elementary category may be a ship, in which case the categories k are congruent with the IMO number, or, more meaningfully, it can be a combination of ship type, size class, and or route.

In each elementary category k (=1, $\ldots$, K), a varying number of fixtures per time period n_{tk}, $t = 1, \ldots, T$, may be observed. Let p_{tkj} be the fixture price of each individual contract j in category k and in period t. This price is synonymous with freight rate, which is the same as the transaction amount agreed on by the ship owner and the charterer for the execution of the transportation service: one contract, one freight rate, one transportation service for the specified duration. Then for each period t and category k, an elementary freight rate is calculated as the weighted arithmetic average, median or geometric average of all fixtures in the sample:

$$
\begin{aligned}
p_{tk}^{A} &= \sum_{j=1}^{n_{tk}} w_{tkj} p_{tkj} \\
p_{tk}^{M} &= Q_2(p_{tk,1}, \ldots, p_{tk,n_{tk}}) \\
p_{tk}^{G} &= \Pi_{j=1}^{n_{tk}} p_{tkj}^{w_{tkj}}
\end{aligned}
\tag{1}
$$

The weights w_{tkj} are defined as the shipped volume d_{tkj} as a portion of total shipped volume $w_{tkj} = d_{tkj}/d_{tk}$, with $d_{tk} = \sum_{j=1}^{n_{tk}} d_{tkj}$.

Calculation of these elementary prices is necessary because generally more than a single transportation service is carried out in each elementary category and period considered. Moreover, the median and geometric mean are advanced as alternative ways to estimate the typical price in a transportation category. The median price has the advantage of being insensitive to incidentally high or low prices, while the geometric mean has the advantage of being less sensitive to extreme outcomes in skewed distributed prices. Note that a geometric mean is always below or at most equal to the arithmetic average. The more variation in the underlying prices, the larger the difference between the two measures. Also note that the differences apply to the averages, not to the index (the ratio of the averages).

For each transportation category k, elementary freight rate indices are straightforwardly obtained as the ratio of current elementary freight rates over the freight rates in some reference period t_0:

$$
I_k^m(t, t_0) = \frac{p_{tk}^m}{p_{t_0,k}^m}
\tag{2}
$$

where m (= A, Q, G) refers to the method of calculating the elementary prices. In the case of LSE's TTC index, the year 1985 is the base period, while the analysis below takes 1997, the first year of the observation period, as the base year.

Chained freight rate indices can be obtained by setting the reference period equal to the preceding period $t-1$, and subsequently chaining the resulting period-to-period indices $I_k^m(t, t-1)$, yielding:

$$
I_k^m(t, \ldots, t_0) = \frac{p_{tk}^m}{p_{t-1,k}^m} I_k^m(t-1, \ldots, t_0)
\tag{3}
$$

In this specific case, chaining takes no effect, since the fixtures included in the two adjacent periods are not matched. The chained unit value indices (3) are therefore identical to the fixed base period indices (2).

In addition to reports of freight rate developments per elementary category, aggregate indices are often wanted in view of the large amount of elementary categories or for other reasons. In the examples below, we shall present freight rate indices by ship type (bulk carrier or tanker) and type of contract (spot or time charter) using elementary indices based on an additional segmentation by size class. These aggregate freight rate indices are simply determined as weighted averages of the elementary indices for each of the three methods m (= A, Q, G) as:

$$I_U^m(t, t_0) = \sum_{k=1}^{K} s_{tk} I_k^m(t, t_0) \tag{4}$$

where the weights s_{tk} are obtained as the shares of shipped tonnage $d_{tk} = \sum_{j=1}^{n_{tk}} d_{tkj}$ in segment k: $s_{tk} = d_{tk} / \sum_{k'=1}^{K} d_{tk'}$, for each period $t = 1, \ldots, T$.

5.2 Comparison with market indices

We evaluate the unit value freight rate indices for the MRI fixtures data base, which is used by Maritime Research Inc. (1970 - current) for their freight rate indices. Lloyd's Shipping Economist (LSE) publishes freight rate indices for bulk carriers in the size categories (LSE index weights between parentheses): Babysize, 0-<12,000 dwt ($s_{t,1}$=0.00); Handysize, 12-<20,000 dwt ($s_{t,2}$=6.77); Handysize, 20-<35000 dwt ($s_{t,3}$=4.34); Handymax, 35-<50,000 dwt ($s_{t,4}$=3.46); Panamax, 50-<85,000 dwt ($s_{t,5}$=2.17); and Capesize, ≥85,000 dwt ($s_{t,6}$=1.68). MRI does not publish sub-indices for different size classes. These size categories are different from the ones presented above, and are only used here for comparison purposes. In the remainder, we will use the size classes as reported in tables 1 and 2. The index weights have remained fixed for an unknown period of time. The overall index will therefore not capture recent developments in the very small-sized and very large-sized categories. The base year for the TTC index is 1985 (TTC index=100) and for the MRI index 1972 (MRI index =100).

In the case of the TTC index, the weights w_{tkj} are set equal to the deadweight tonnage d_{tkj} shipped under fixture j as a fraction of total tonnage shipped in period t and category k, $w_{tkj} = d_{tkj} / \sum_{j'=1}^{n_{tk}} d_{tkj'}$. Unweighted averages could be obtained by letting w_{tkj} = $1/n_{tk}$ for all fixtures j in the relevant time period and transportation category.

We first present a comparison of our overall index. We compare the LSE TTC index with our own general unit value index calculated using the LSE aggregation weights, as well as with a general unit value index with size classes based on the size classes in tables 1 and 2 and using general weights based on the total volume carried. We calculate differences between indices by the average absolute difference between two indices, and by this average absolute difference relative to the average level of the benchmark index (usually our weighted unit price index, unless otherwise stated).

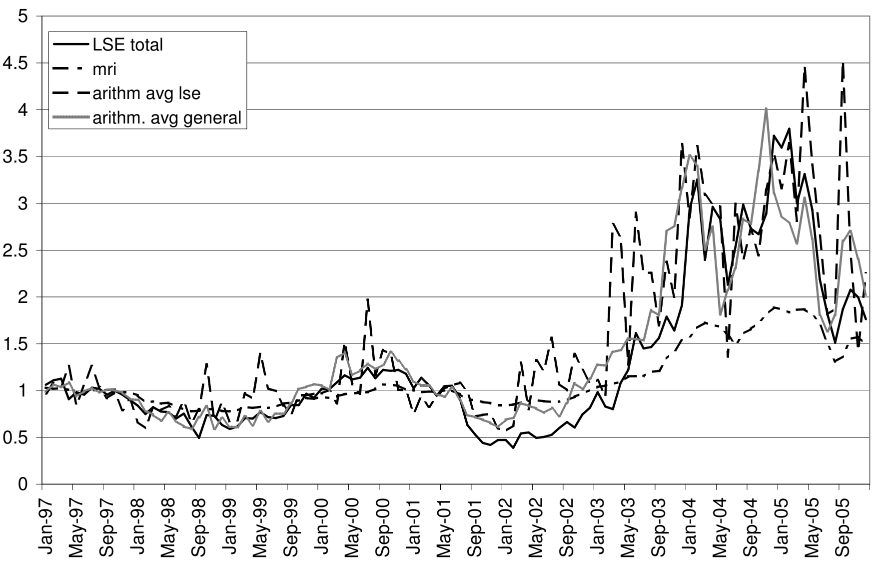
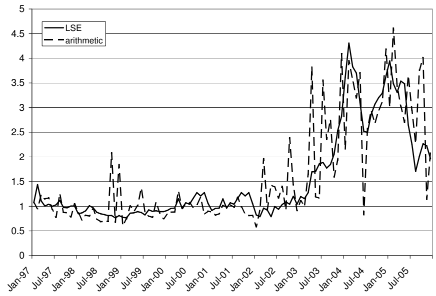


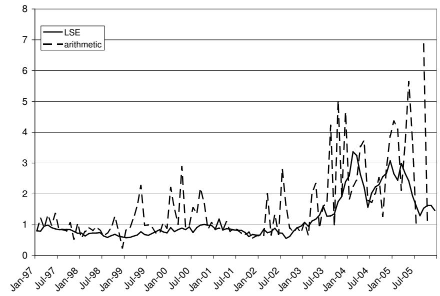
Figure 2: comparison weighted unit value indices with LSE and MRI overall indices

From figure 2 we observe that the four indices are very different, even though the long term cycle seems to be the same in all four. The MRI index is very dissimilar compared to the general unit value index: average absolute difference and the relative average absolute difference relative to our general weighted unit value index are 0.37 and 26.5%, while the LSE TTC index is dissimilar to the unit value index calculated 'in the LSE way': 0.34 and 22.3%. Furthermore, the LSE and MRI indices are differ considerably from each other, whereas both purport to portray market developments in dry bulk shipping: 0.35 and 31.7%.

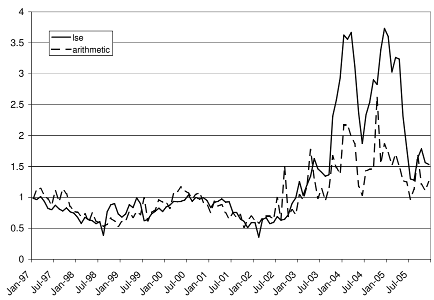
Figure 3 compares LSE's subindices with our own subindices evaluated for the segmentation adopted by LSE. The comparison is only for the dry bulk shipping industry. Again, the LSE indices, which are supposed to be simple weighted unit value indices, are found to be quite different from our weighted unit value indices, even though they capture the same long term cycle, and many of the peaks and troughs coincide. The average absolute difference between our indices and the LSE indices are (relative differences with respect to our unit value indices are between parentheses): 0.38 (24.1%) for Handysize, 0.61 (38.6%) for Handymax, 0.37 (36.0%) for Panamax, and 0.23 (16.5%) for Capesize. The bigger absolute differences occur from the second half of 2003 onwards. One reason for these differences could be the underlying data set, but we do expect considerable overlap between the LMIU fixture database used by LSE and the MRI fixture database used in the present research. This is also apparent from the fairly



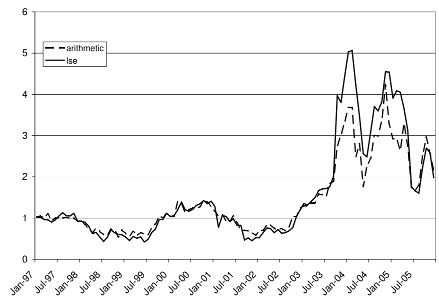
(a) handysize



(b) handymax



(c) panamax



(d) capesize

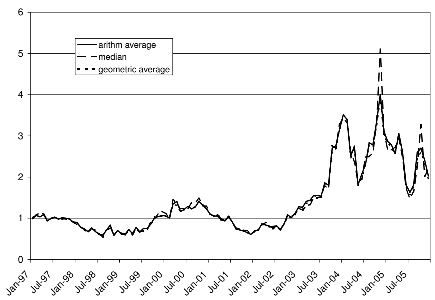
Figure 3: Comparison LSE-weighted unit value indices by size class

Size class intervals are: handysize 20-35000 dwt, handymax 35-50000 dwt, panamax 50-85000 dwt and capesize 85000 dwt+

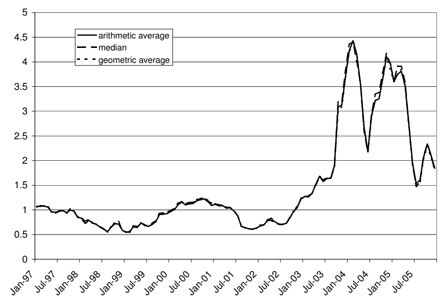
close correspondence of our unit value indices and the LSE indices until mid 2003. The closest correspondence overall is obtained in the Capesize series 3(d). This is also the size class with the largest number of fixtures.

5.3 Weighted unit value index calculation

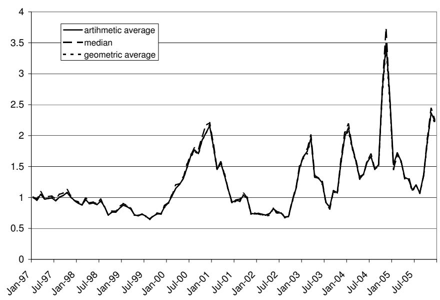
In figure 4 we present the results for the overall weighted unit value indices for bulk carriers and tankers, spot and period charter contracts, based on arithmetic averages, geometric average and the median.



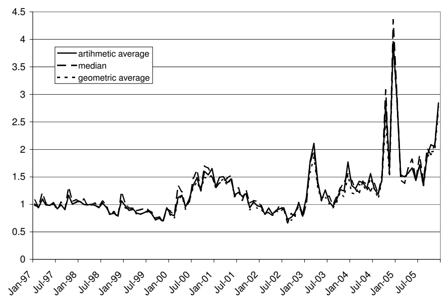
(a) bulk spot



(b) bulk period



(c) tankers pot



(d) tanker period

Figure 4: Weighted unit value indices for bulk carriers and tankers

From figures 4(a) to 4(d) it is clear that the three calculation methods do not lead to remarkably different indices. The average absolute and relative differences between the indices based on median and geometric averages and those based on arithmetic averages are equal to 0.08 (5.6%)/0.03 (1.8%), 0.03 (1.9%)/0.01 (0.8%), 0.03 (2.2%)/0.01 (1.0%) and 0.07 (5.9%)/0.04 (3.4%) for bulk spot, bulk time, tanker spot and tanker time charter contracts, respectively. The largest differences can be observed for arithmetic and median-based indices in the case bulk spot and tanker time charter contracts. It should be mentioned, however, that for some size classes and contract types, the differences are much more pronounced. For bulk spot Handysize and Handymax the various indices differ to some degree, and the tanker time charter Handysize and Aframax indices also show differences between the arithmetic and geometric averages and the median based index (the other tanker time charter sub-indices have too many missing values to be compared). These series are all characterized by thin underlying data sets of fixtures, with a lot of months missing completely.

Comparing weighted and unweighted unit value indices

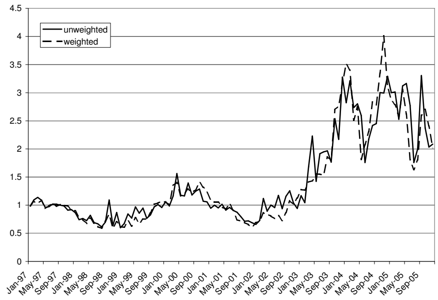
The overall indices in the previous section were obtained by weighting the subindices with the total cargo volume per size class. Here we compare the these weighted overall indices with overall indices determined as unweighted averages of the size class subindices.

The figures show that there are differences between the weighted and unweighted overall series for bulk spot charter contracts and tanker time charter contracts. The average absolute and relative (with respect to the weighted indices) differences between the unweighted and weighted indices are: 0.17 (11.8%) for bulk spot charter, 0.08 (5.1%) for bulk time charter, 0.05 (4.1%) for tanker spot charter, and 0.07 (5.8%) for tanker time charter. For the bulk spot case, the differences are found to be substantial. The largest monthly difference is as much as one index point in November 2004. Again, we find the largest differences in the two fixture categories for which the number of fixtures is relatively the small.

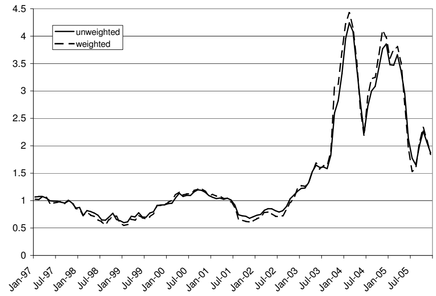
5.4 Disadvantages of unit value freight rate indices

A general issue of unit value indices is that the prices considered in the two periods (the numerator and the denominator in the indices) may relate to different sets of products or services. Consequently, the price indices reflect not only price movements but also changes in the number and nature of services provided. This is even more an issue for the reporting of pure average freight rates, than for the unit value indices. Only when the underlying product or service is rather homogeneous, will the impact of this problem be limited.

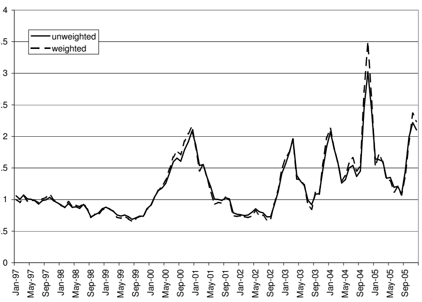
The problem is aggravated by the differences between the numbers of fixtures between periods. A solution would be to employ a more specific matching approach, for instance by matching individual ships. In principle, our data set would allow this, since we often have multiple fixtures for the same ship. The problem is, however, that ships switch between spot and period markets, which means there are gaps in the strings of



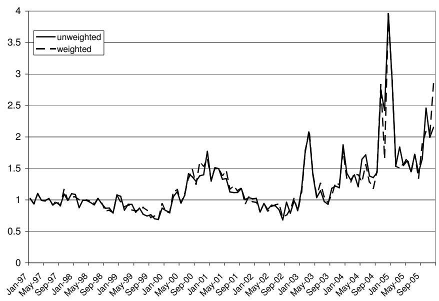
(a) bulk spot



(b) bulk time



(c) tanker spot



(d) tanker time

Figure 5: Weighted versus unweighted overall unit value indices for bulk carriers and tankers

fixtures. Also, ships go missing for periods of time for other reasons: they engage in unobserved contracts, they go into maintenance or repair, they are waiting for business, or their contract extends over more than a month to execute. As a result, direct matching on the basis of ship ID (IMO number) is not feasible. In the next section, we do present matched indices, based on routes within our ship size class segments.

6 Matched model indices

The calculation of matched model indices requires the notion of a 'model', product or service that is sufficiently homogeneous to meaningfully compare its associated prices in subsequent periods. For consumer products this can usually be done but for services in general and unique service agreements such as fixtures, this is more problematic. In the previous analysis of unit prices per segment (by ship type and size class) we ignored the potential existence of homogenous services within the distinguished segments. More specifically, the segmentation by route was not been performed, largely due to lack of data. In this section, we do take this information into account by matching average freight rates for identical routes in a given segment. We shall first present the definitions of the matched model indices used, and then consider applications to the development of spot fixture rates only, because time charter contracts do not specify route information.

6.1 Matched model index calculation

As with the unit value indices, we calculate average freight rates for each elementary category $k = 1, \ldots, K$ in period t. But this time the categories are broken down by route (depending on availability) in addition to ship type and size class. Calculation of these elementary prices is necessary because the same route can easily occur more than once in the period considered. Denote the number of routes in each category and period as L_{tk}, and the number of fixtures on each route as n_{tkl}, $\sum_{l=1}^{L_{tk}} n_{tkl} = n_{tk}$ for all segments k. Moreover, let p_{tklj} be the freight rate of fixture j on route $l = 1, \ldots, L_{tk}$ and d_{tklj} the associated shipped volume. Elementary prices are now calculated for all routes, segments and periods conform (1) as:

$$\begin{aligned} p_{tkl}^{A} &= \sum_{j=1}^{n_{tkl}} w_{tklj} p_{tklj} \\ p_{tkl}^{M} &= Q_2(p_{tkl,1}, \ldots, p_{tkl,n_{tkl}}) \\ p_{tkl}^{G} &= \Pi_{j=1}^{n_{tkl}} p_{tklj}^{w_{tklj}} \end{aligned} \tag{5}$$

The weights w_{tklj} are shipped volumes d_{tklj} stated in each fixture as a portion of the total shipped volume on the route $d_{tkl} = \sum_{j=1}^{n_{tkl}} d_{tklj}$, $w_{tklj} = d_{tklj}/d_{tkl}$.

Period-to-period matched model indices are constructed as weighted sums of price relatives over the observed routes and chaining the result. A Laspeyres-like freight rate index for the (arithmetically weighted average) prices two adjacent periods in segment k is defined as:

$$I_{t,t-1}^{L,A} = \frac{\sum_{l=1}^{L_{tk}} d_{t-1,kl} p_{tkl}^{A}}{\sum_{l=1}^{L_{tk}} d_{t-1,kl} p_{t-1,kl}^{A}} = \sum_{l=1}^{L_{tk}} w_{t-1,kl} \frac{p_{tkl}^{A}}{p_{t-1,kl}^{A}} \tag{6}$$

The weights $w_{t-1,kl}$ are calculated as the value shares of each route in the preceding period $w_{tkl} = d_{t-1,kl} p_{t-1,kl}^{m} / \sum_{l'=1}^{L_{tk}} d_{t-1,kl'} p_{t-1,kl'}^{m}$. Prices without a match in either the current or preceding period drop from the index calculation; no attempt is made to impute these missing prices. A Paasche-like index is similarly obtained as:

$$I_{t,t-1}^{P,A} = \frac{\sum_{l=1}^{L_{tk}} d_{t,kl} p_{t,kl}^{A}}{\sum_{l=1}^{L_{tk}} d_{t,kl} p_{t-1,kl}^{A}} = \left(\sum_{l=1}^{L_{tk}} w_{t,kl} \left(\frac{p_{t,kl}^{A}}{p_{t-1,kl}^{A}} \right)^{-1} \right)^{-1} \tag{7}$$

In this case, the elementary price relatives per route are weighted by the value of the fixtures in the current period.

A disadvantage of the Laspeyres and Paasche indices is that they do not adequately cope with substitution effects. In specific, buyers of commodities tend to buy less of the commodities with the higher price increases, and more of the commodities with the lower price increases. As a result, a Laspeyres price index tends to overestimate the price developments, while a Paasche price index underestimates the general price movement. The Fisher index counters this problem by calculating the geometric average of the Laspeyres and Paasche indices:

$$\begin{aligned} I_{t,t-1}^{F,A} &= \left(I_{t,t-1}^{L,A} \right)^{1/2} \left(I_{t,t-1}^{P,A} \right)^{1/2} \\ &= \left(\sum_{l=1}^{L_{tk}} w_{t-1,kl} \frac{p_{tkl}^{A}}{p_{t-1,kl}^{A}} \right)^{1/2} \left(\sum_{l=1}^{L_{tk}} w_{t,kl} \left(\frac{p_{t,kl}^{A}}{p_{t-1,kl}^{A}} \right)^{-1} \right)^{-1/2} \end{aligned} \tag{8}$$

Correspondingly, freight indices for the geometrically weighted elementary prices can be determined by taking geometric rather than arithmetic averages of the price relatives, which leads to the geometric Laspeyres and Paasche, and the Törnqvist price indices:

$$I_{t,t-1}^{GL,G} = \Pi_{l=1}^{L_{tk}} \left(\frac{p_{t,kl}^{G}}{p_{t-1,kl}^{G}} \right)^{w_{t-1,kl}} \quad (9)$$

$$I_{t,t-1}^{GP,G} = \Pi_{l=1}^{L_{tk}} \left(\frac{p_{t,kl}^{G}}{p_{t-1,kl}^{G}} \right)^{w_{t,kl}} \quad (10)$$

$$I_{t,t-1}^{GF,G} = \left(I_{t,t-1}^{GL,G} \right)^{1/2} \left(I_{t,t-1}^{GP,G} \right)^{1/2} = \Pi_{l=1}^{L_{tk}} \left(\frac{p_{t,kl}^{G}}{p_{t-1,kl}^{G}} \right)^{(w_{t-1,kl}+w_{t,kl})/2} \quad (11)$$

Though one can apply the Laspeyres and Paasche indices to geometrically weighted prices or, conversely, apply the geometric indices to arithmetically weighted prices, we decided in favor of consistency.

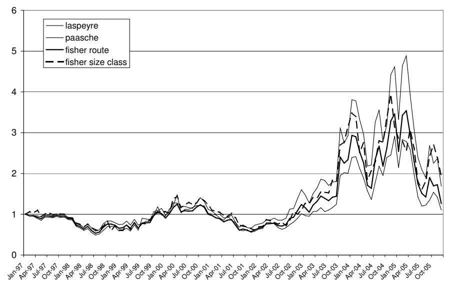
In addition, index series for the entire observation period are obtained by chaining the period-to-period indices, as in (3). Aggregate indices over all segments K are constructed in line with (4). Below we apply these indices to freight rate developments for fixtures in the spot market.

6.2 Matched model results

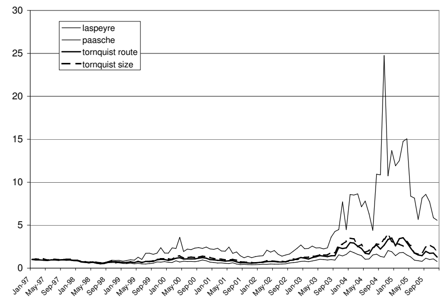
We have grouped the indices based on the use of the arithmetic or geometric average to calculate the elementary prices. For comparison, we have calculated matched model indices that consider all fixtures in a size class to be homogeneous products. These indices are obviously almost completely the same as the weighted unit value indices introduced above (the average absolute differences of the matched model indices by size class and the weighted unit value indices are, for dry bulk and tankers respectively, are 0.01 (1.0%) and 0.02 (1.7%) - relative against the weighted unit value indices.

The average absolute differences in absolute terms and relative terms between the Fisher and Törnqvist matched model indices by route and the matched model indices by size class are 0.18 (12.7%), 0.17 (12.4%), 0.08 (6.8%) and 0.09 (7.0%), for the dry bulk Fisher, dry bulk Törnqvist, tanker Fisher and tanker Törnqvist indices, respectively (relative against the matched model indices by size class).

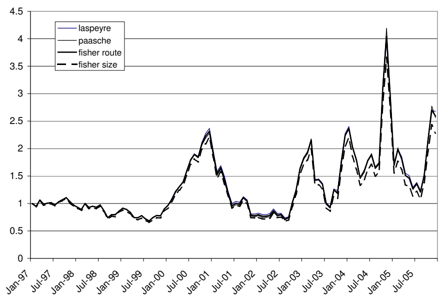
This result are interesting, in the sense that many of the market indices, notable the MRI grain sub-index, the SSY Capesize indices, the JE Hyde indices are indices for a specific size class based on a set of selected routes (which could be interpreted as a form of matching by route). For Capesize ships, for instance, the difference between the Fisher indices matched by route and size class is even more pronounced than



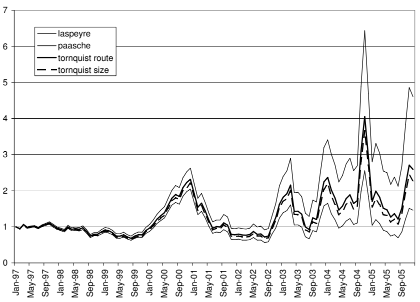
(a) bulk arithmetic average



(b) bulk geometric average



(c) tanker arithmetic average



(d) tanker geometric average

Figure 6: Comparison matched model indices for bulk and tanker spot charter contracts

The labels 'route' and 'size' refer to the matched model indices that are matched by route or size class, respectively. In all four cases, the Laspeyres index is the top index, while the Paasche index is the bottom index.

the average absolute difference figures for the overall indices: 0.20 (14.4%), the index matched by size class being consistently higher. Given that an average Capesize spot contract maybe valued at around 26 $/ton for 160.000 dwt, a deviation of 14% constitutes a value of $582.000.

7 Hedonic indices

We calculate indices that are corrected for quality developments over time. We estimate a hedonic model that includes ship size, ship age, the origin area of the contracts (for spot) and the contract duration as quality variables. Below, we specify the calculation of these hedonic indices and the models used to estimate the hedonic relations.

7.1 Calculation of hedonic indices

The idea of hedonic analyses stems from household production theory (Lancaster, 1966a,b) interpreting commodities or services as bundles of observable characteristics that have value for buyers. Relating product prices to the observable characteristics allows one to estimate the implicit prices of constituent characteristics, which can then be used in price index calculations. Early applications of this quality characteristics model to automobile prices date from (Court, 1939) and later (Griliches, 1971). A related alternative approach based on the repackaging theory by Fisher and Shell (1971) (see also Muellbauer (1974)) directly estimates period-to-period price changes through pooled regressions of prices on time dummies and product characteristics. These quality characteristics may include age information to cope with deterioration, and even vintage effects (cf Hall, 1971; Berndt et al., 1995). A recent, more extensive exposition of the hedonic method can be found in Triplett (2006).

We apply the latter repackaging method to find quality-corrected estimates of the freight rate developments controlling for freight and ship specific characteristics like size (in dwt) and age of the ship (in years),and fixture characteristics like contract duration (in days) and region of origin (dummies for nine regions, only for spot contracts). The estimated regression models are of the form:

$$\ln p_{tkj} = \beta_t + \pi_t dt_t + \mathbf{x}'_{tkj}\boldsymbol{\beta}_t + \epsilon_{tkj} \tag{12}$$

Here, $\mathbf{x}'_{tkj}$ contains the mentioned quality characteristics, and ϵ_{tkj} is an identically and independently distributed random term with mean zero and variance σ_t^2. The model is estimated both repeatedly over time using fixture information of two adjacent periods

(dt_t is a scalar dummy variable with one for the current period, and zero for the preceding period) and at once using information of all periods pooled (dt_t is a vector of dummy variables for all periods except the base period). The use of log-transformed freight rates as the dependent results in quality corrected freight rate changes being readily obtained from:

$$I^{H,A}_{t,t-1,\ldots,1} = \exp(\hat{\pi}_t) I^{H,A}_{t-1,\ldots,1} \quad (13)$$

$$I^{H,P}_{t,t-1,\ldots,1} = \exp(\hat{\pi}_t) \quad (14)$$

The interpretation of $\exp(\hat{\pi}_t)$ as estimated quality-corrected change of freight rates follows from the fact that $\pi_t = E(\ln p_{tkj}|dt_t = 1, \mathbf{x} = \mathbf{x}^*_{tkj}) - E(\ln p_{tkj}|d_t = 0, \mathbf{x} = \mathbf{x}^*_{tkj})$. The adjacent period freight rate index (13) is obtained by chaining the $\exp(\hat{\pi}_t)$ over time, whereas the pooled period index (14) immediately follows from the estimated dummy effects.

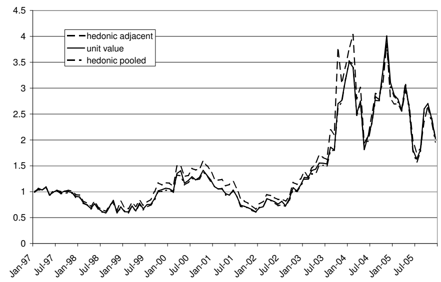
7.2 Application to spot and time contracts for bulk and tanker markets

We calculate the hedonic freight rate indices for spot and time charter fixtures in the bulk and tanker markets separately. The resulting indices are depicted in figure 7.

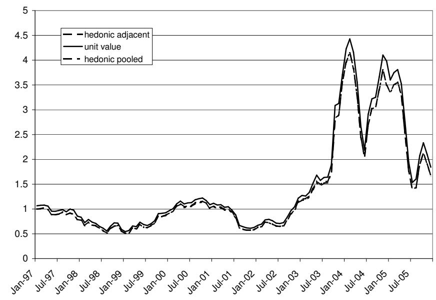
The average absolute differences in absolute terms and relative to the weighted unit value indices are 0.12 (8.5%), 0.10 (6.9%), 0.02 (1.7%), 0.36 (29.5%) and 0.03 (2.3%), 0.11 (7.3%), 0.02 (1.2%) and 0.10 (7.7%), for the adjacent model for dry bulk spot, dry bulk time, tanker spot and tanker time, and for the pooled model for dry bulk spot, dry bulk time, tanker spot and tanker time, respectively.

The fact that the pooled hedonic indices are all fairly close to weighted unit value indices is an indication that on average, there is little difference between our unit value index and the quality corrected index. In other words, there is not really a two-tier market for high and low quality shipping. That there are substantial differences between the unit value indices and the adjacent hedonic indices is then an indication that these differences do exist from time to time, but that they are transient. This finding is in line with investigations of Tamvakis and Thanopoulou (2000) (for dry bulk) and Strandenes (1999) (for tankers), who also find that two-tieredness exists but only for short periods of time, mostly when the market is not very tight, and charterers have the luxury of choice. It is not surprising, therefore, that around the time the market did get tight (end of 2003, beginning 2004), the difference between the dry bulk spot unit value index and the corresponding adjacent hedonic index disappears (and even becomes negative for a while).

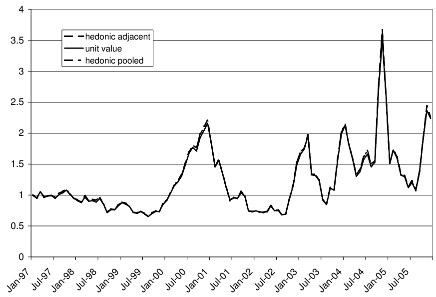
The tanker time charter indices show erratic results. There are several explanations.



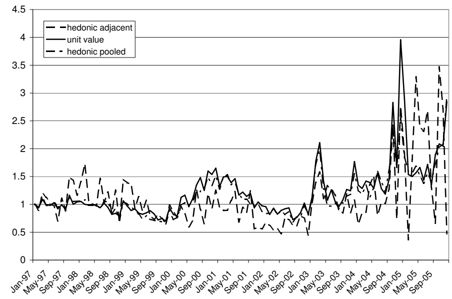
(a) bulk spot



(b) bulk period



(c) tanker spot



(d) tanker period

Figure 7: comparison hedonic-weighted unit value indices

All indices are weighted with cargo volume.

The most likely is the fact that we included contract duration in the hedonic model, and for tanker time charters the average durations were rather long (up to two years on average). However, this category of fixtures also contains a large subset of lightering contract, that may show more erratic pricing development. Given that these contracts do not have a long duration, this pricing pattern probably shows through in the adjacent hedonic index.

8 Duration indices

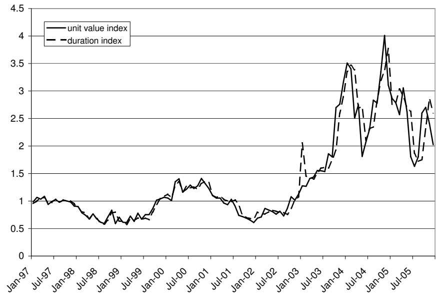
A notable difference between the present indices and indices calculated for cars, apparel and other commodities, is that the sample of prices is concerned with transaction prices instead of list prices. Moreover, prices are quotes in $/ton or $/day, which is more related with the notions of rental prices and user costs than with acquisition prices.

A rental agreement has a price as well as a duration component. The information about duration in the contracts is ignored in the unit price indices presented in the previous sections and all the dry bulk and tanker indices used in practice.

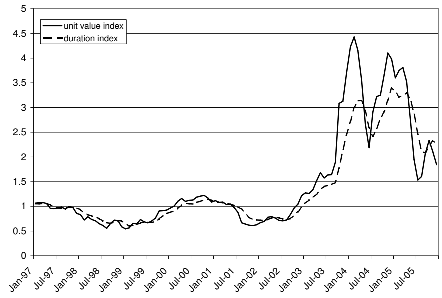
The time charter fixtures have duration as an attribute. The spot charter fixtures do not contain duration information directly, but it can be inferred from the information in the fixtures in various ways. First of all, a number of fixtures contain the dates on which the fixture is supposed to start and end. The period between these dates can be taken as the duration of the fixture. If these dates are not known, the specified distance of the fixture along with the speed of the ship can be used to calculate the required time to execute the fixture. This time can be added to the start of the fixture date, if it is present, and otherwise to the reporting date of the fixture, to have an estimate of the end date. If the speed of the ship was missing, we used the average speed of 13.5kn (13.5 nautical miles per hour).

Subsequently, we apply the fixture information to every day in the start and end date window of the fixture. In many cases, this carries the price of the contract into the next month(s). As a result, the indices will no longer reflect contracting prices, but the average price of all ships under contract. To calculate the indices, we use the same formulas as presented in previous sections. As a consequence of this approach, the indices are now automatically weighted by the duration, but proportionally split up over the months in which the contract falls. Below, we present comparisons for the dry bulk and tankers overall indices.

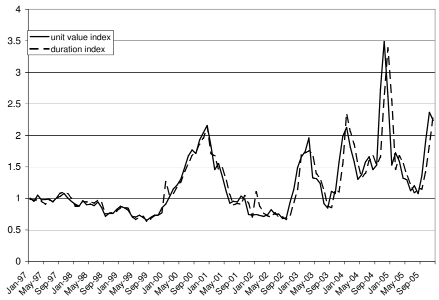
The average absolute differences in absolute terms and relative to the weighted unit value indices are 0.13 (9.6%), 0.23 (15.5%), 0.14 (11.2%), 0.29 (23.9%) for the dry bulk spot, dry bulk time, tanker spot and tanker time charter indices, respectively. These figures show that the largest impact is found in the time charter indices. This is to be



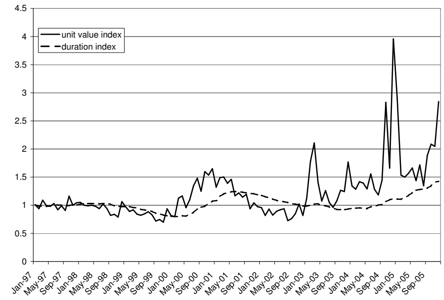
(a) bulk spot



(b) bulk time



(c) tanker spot



(d) tanker time

Figure 8: comparison duration-weighted unit value indices

All indices are weighted with cargo volume.

expected, since time charter contracts had a much longer duration than spot contracts (see table 5).

We thus find that taking duration into account in time charter indices has quite an impact. This finding is in contrast with the common practice in the industry to include both spot and time charter contracts in one index (some of the Baltic Exchange indices, the SSY Capesize indices, for instance). If duration would be taken into account, the average time charter prices to be included in these indices would change considerably.

The analysis of the tanker time charter indices reveals that the duration approach leads to very considerable smoothing. The unit value tanker time charter index did contain some extreme peaks that have disappeared completely in the duration index. The reason for these peaks is as follows. Observation of the fixtures reveals that there are around 700 very short term time charter contracts in the data set (38% of the total) which are so-called lightering contracts. These are contracts for just a few days for shuttling between an oil platform and a coastal pumping station or storage park, which are paid in $/day. In essence, these contracts are very different from time charter contracts with duration of several months to several years, and the pricing can also be wildly different. In the duration index, with its implicit weighting by contract duration, these short contracts, even though they may have extreme prices sometimes, have very little impact on the overall index.

9 Conclusions

In this paper, we have explored the possibilities for index calculation for prices of ocean charter contracts. We have suggested several different approaches to index calculation (indices based on arithmetic, geometric average or median, weighted and unweighted aggregation, matched model indices, quality correction and, finally, the inclusion of contract duration) and we benchmarked our results against existing indices in the industry.

Our findings can be summarized as follows. We find that existing indices present wildly different insights in market developments. The patterns that our indices display is not very similar to that of these existing indices. Large differences appear especially in more recent years (2003-2005). Furthermore, we find that using different calculation methods (arithmetic average, geometric average, median), weighted or unweighted aggregation, matching and quality correction gives much larger differences for the categories (bulk spot and tanker time charter contracts) with a limited amount of data. In other words, if there is an abundance of contracts, weighted unit value indices are quite robust to weighting, matching and quality correction. This has important repercussions for the presentation of indices by the industry. Most of these are based on thin data sets or data sets in which the number of fixtures fluctuates substantially over time. This means that knowledge of the calculation method is essential in interpreting the index and relying on them for investment and contracting decisions.

The matched models indices also show that the calculation of indices on the basis of a fixed set of routes can lead to quite different results both for different calculation methods (arithmetic or geometric average) and different types of indices (unit value, Laspeyres, Paasche, Fisher, Törnqvist). In some cases (geometric Laspeyres, in combination with a thin data set), the index can even reach highly inflated values. The industry practice of always using the same set of selected routes combined with the practice of expert assessments to fill in gaps in the data may have much more impact on the indices than the industry realizes.

We show that duration indices provide very different results especially for the time charter contract indices. This questions the validity of time charter indices, as well as other industry indices that include time charter prices. As such, it may also prompt a new look at some of the charter term structure research that has been presented over the last decade or so, given that this was based on contracting indices for the representation of the time charter market.

Overall, we find that many of the industry indices are unreliable as indicators of market developments in shipping. Furthermore, we question the validity of some of the academic research that was carried using databases that include these indices. We therefore see many avenues for further research, from collecting more data from other sources to investigate the issue of data coverage, to redoing some of the advanced time series analysis on non-linearity, time varying volatility and term structure analysis in the industry.

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