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Oil Prices and Maritime Freight Rates: An Empirical Investigation

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Abstract

The study assesses the effect of oil prices on maritime freight rates for containerized goods and two particular commodities, iron ore and crude oil. As regards container transport, the study relies on Containerisation International quarterly container freight data (1993–2008) for the three main East–West container trade routes, namely, the transpacific, the transatlantic and the Asia–Europe. For iron ore, eight commercial routes are considered using Drewry’s monthly (1993–2008) spot iron ore freight rates, as published in UNCTAD’s Iron Ore Statistics, while the analysis of crude oil freight rates is based on Drewry’s monthly spot tanker rates (1996–2008) on eight commercial routes. Using regression analysis, the elasticity of freight rates to oil prices is found to be dependent on the market under consideration, as well as on the specification. For containerized trade, the estimated elasticity ranges between 0.19 and 0.36; a similar elasticity is estimated for crude oil carried as cargo: 0.28. For iron ore, on the other hand, the estimated elasticity is much larger, approximately equal to unity. Results also indicate that, since 2004, the elasticity of container freight rates to oil prices is larger; this suggests that the effect of oil prices on container freight rates increases in periods of sharply rising and more volatile oil prices. The results are of particular interest in view of increasing oil supply constraints expected over the coming decades which may lead to significant increases in oil prices, possibly to levels which have not yet been reached. Against this background and in view of the heavy reliance of maritime transport on oil for propulsion, further analytical work on the effect of energy prices on maritime freight rates, is urgently required, in particular as rising fuel costs may lead to proportionately higher maritime transport costs for developing countries. In this context, energy security and investment in alternative and greener energy and technology for cost-efficient and sustainable maritime transportation that enable trade and development are of the essence.

A. INTRODUCTION

1. Oil is the major energy source powering the global economy and supplying 95 per cent of the total energy fuelling world transport.¹ Like other modes, maritime transport relies heavily on oil for propulsion and, in view of limitations imposed by existing technology and costs,² is not yet in a position to adopt effective energy substitutes (e.g. biofuels, solar and wind). At the same time, fossil fuel reserves are finite, oil extraction is becoming increasingly costly and oil production overall is believed to either already have peaked or to reach its maximum level soon.³ The dependency of the maritime transport sector on a source of energy that is becoming increasingly scarce and more costly to produce, compounded by limited prospects, at least in the short term, for using alternative energy may entail some serious implications for the cost of maritime transport services. With over 80 per cent of the volume of global merchandise trade being carried by sea,⁴ the question of how changes in oil prices affect ocean shipping rates is of considerable relevance.

2. The broader question regarding the implications of rising and volatile oil prices for transport costs and trade is very important, especially for developing countries. For a number of these countries, international transport costs are already significantly high and can often surpass customs duties as a barrier to international trade. Prohibitive transport costs affect in particular the most vulnerable countries, such as landlocked and island developing countries by reducing their transport connectivity and hindering their ability to participate in the global trading system.⁵

3. In the midst of the 2007/2008 hike in oil prices – when the oil price (as shown by the Brent spot crude oil price), increased by almost 150 per cent between January 2007 and July 2008, reaching a peak of close to \$150 per barrel (pb)⁶ – some trade observers argued that increased transport costs due to higher oil prices may reverse globalization and cancel out the comparative advantage of low cost remote production locations such as China.⁷ However, observed trends in shipping freight rates indicate that while higher oil prices had immediately

¹ See for example IPCC (2007). See also estimates by the World Business Council on Sustainable Development, WBCSD (2004). In 2030, transport energy use is forecast to be about 80 per cent higher than in 2002 with almost all of this new consumption expected to be in petroleum fuels. Worldwide transportation fuel consumption is projected to double by 2050 despite significant energy efficiency gains.

² For additional information, see IMO (2009). See also UNCTAD (2009(b)), Chapter 1, Section D.

³ Projections include those by the International Energy Agency (IEA), the United States Energy Information Administration (EIA) and the Association for the Study of Peak Oil (ASPO – <http://www.peakoil.net>). For an overview of the peak oil debate, see Jasmin and Ryan (2008); Robert (2008); Aleklett (2007); and Jeremy Leggett at <http://www.jeremyleggett.net>. See also NPC (2007).

⁴ UNCTAD estimate based on international seaborne trade data for 2008 and global trade data for 2008 supplied by Global Insight in 2007. This share amounts to 90 per cent of world merchandise trade when intra-European trade is excluded.

⁵ For example, freight costs on ad valorem basis for a landlocked country such as Rwanda amounted to over 24 per cent of the value of imports in 2004 (about 7 times the global average). See latest estimates available of freight costs published in UNCTAD (2006): chapters 4 and 7.

⁶ United States Energy Information Administration (EIA): daily and monthly Europe spot prices FOB (dollars per barrel).

⁷ See for example Rubin and Tal (2008), who argue that increased oil prices significantly impact global trade and production processes and might reverse a significant amount of globalization.

translated into higher fuel costs,⁸ an equivalent rise in ocean freight rates did not materialize.⁹ While oil prices may explain some of the variation in maritime transport costs, other factors are also at play.¹⁰ These include, for example, (a) demand for shipping services (e.g. trade volumes); (b) port-level variables (e.g. the quality of port infrastructure); (c) product-level variables (e.g. value/weight ratios and product prices); (d) industry-level variables (e.g. the extent of competition among shippers and carriers); (e) technological factors (e.g. the degree of containerization, size of ships and economies of scale); (f) institutional variables (e.g. legislation and regulation); and (g) country-level variables (e.g. attractiveness of export markets).¹¹

4. Against this background and in accordance with UNCTAD's mandate in the field of transport and trade facilitation as well as energy,¹² the objective of the present study is to improve the understanding of the effect of rising and volatile oil prices on maritime freight rates. Towards this objective, regression analysis is used to estimate the elasticity of maritime freight rates to oil prices (used as proxy for bunker fuel costs), focusing, in particular, on the container transport. The study also attempts to extend the analysis to cover some dry and wet bulk trades (i.e. iron ore and oil).

5. In view of the complexity and intertwined nature of the determinants of maritime transport costs,¹³ it is hoped that insights gained from the present study will help further clarify the dynamics of shipping freight markets and of the effect of oil prices on maritime freight rates. It is also hoped that its findings will contribute to the debate on energy security and climate change on the one hand, and cost-efficient transportation systems as enablers of trade and development, on the other. Energy security and access to sustainable energy sources at a reasonable cost are key to the discussion on how to ensure economic growth and development against a background of considerations relating to environmental sustainability and climate change.

⁸ Reflecting rising oil prices, by the end of 2007, prices for bunker fuel oil (380 cst) had increased by 73 per cent in Rotterdam, 76 per cent in Singapore and 79 per cent in Los Angeles compared to the same period during the previous year. In mid-2008, fuel costs were reported to account for as much as 50 per cent–60 per cent of total operating costs of a shipping company (depending on the type of ship and service). See for example WSC (2008). For the purposes of this study, the distinction between running costs and voyage costs will not be pursued and voyage costs (and therefore bunker costs) are assumed to be reflected in carriers' pricing decisions.

⁹ UNCTAD (2008(a)): chapter 1, section D, page 26.

¹⁰ See for example Hummels (2007); Hummels (2009); OECD (2008) and OECD (forthcoming).

¹¹ While acknowledging the multiplicity of factors that determine maritime freight rates, the analysis of these factors is beyond the scope of the present study, the focus of which is on the effect of oil prices on maritime freight rates.

¹² See in particular relevant provisions of the mandate in the Accra Accord of UNCTAD-XII (UNCTAD/IAOS/2008/2): Paragraph 98: "UNCTAD's work on energy related issues should be addressed from the trade and development perspective, where relevant in the context of UNCTAD's work on commodities, trade and environment, new and dynamic sectors, and services." and Paragraph 164: "UNCTAD should undertake research to develop policy recommendations that will enable developing countries to cut transport costs and improve transport efficiency and connectivity. [...]"

¹³ Oil prices could also affect other transport cost determinants by conferring, for example, a greater or a lesser weight to such factors. For example, higher oil prices can confer a greater weight to "distance" as a determinant of maritime freight rates as shown, for example, in Mirza and Zitouna (2009).

B. A BRIEF OVERVIEW OF THE RELEVANT LITERATURE

6. Research examining the determinants of maritime transport costs and the quest to understand their impact on transport and trade have evolved and intensified over recent years.¹⁴ Existing research has generally considered determinants of transport costs other than fuel prices¹⁵ and has increasingly relied on a reduced form modelling, which is also the approach adopted in the present study. Examples include studies that examine the impact of policy variables such as restrictions on the provision of port services and private practices,¹⁶ the impact of Open Skies Agreements,¹⁷ infrastructure,¹⁸ port efficiency,¹⁹ and the shipping market structure.²⁰ Overall, this literature has not particularly focused on oil prices as a potential transport cost determinant and there is, so far, little econometric evidence on the effect of oil (bunker fuel) prices on maritime freight rates.

7. Studies that have particularly focused on the link between oil prices and transport costs include for example the study by Poulakidas and Joutz (2009) which analysed the impact of the recent spike in oil prices on tanker rates and investigated the dynamics explaining spot tanker rates.²¹ The authors show that there is a relationship between spot and future crude oil prices, crude oil inventories, and spot tanker rates. A study by the Organization for Economic Cooperation and Development (OECD forthcoming) has also investigated, among others, the impact of oil prices on maritime transport costs.²² Depending on the specification, the OECD study estimated an elasticity of freight rates to oil prices ranging from 0.018 to 0.150. Using historical data, Hummels (2007) estimated an elasticity of ocean cargo costs with respect to fuel prices between 0.232 and 0.327. In contrast, Mirza and Zitouna (2009), in a study using United States trade data, estimated a low elasticity of freight rates to oil prices, ranging from 0.088 for countries close to the United States and of 0.103 for faraway countries.

¹⁴ See for example, Radelet and Sachs (1998); Hummels (1999); Hummels (2001); Limão and Venables (2001); Micco and Pérez (2001); Limão and Venables (2002); Clark, Dollar and Micco (2004); Wilmsmeier, Hoffmann and Sanchez (2006); Hummels (2007); OECD (2008); OECD (forthcoming); Hummels (2009); Mirza and Zitouna (2009).

¹⁵ However, the trade literature includes studies that consider the effects of oil prices on trade (directly or indirectly through their impact on transportation costs). See, for example, Backus and Crucini (2000); Hummels (2007); and Bridgman (2008).

¹⁶ See Fink, Mattoo and Neagu (2002), who estimate an econometric model of liner transport prices for United States imports. They find that restrictive trade policies and private anticompetitive practices both matter for maritime transport costs.

¹⁷ Micco and Serebrisky (2006). The study finds that Open Skies Agreements reduce air transport costs in developed and higher income countries by 9 per cent. See also Molina (2008).

¹⁸ Limão and Venables (2001). They conclude that infrastructure is an important determinant of transport costs especially for landlocked countries and Africa.

¹⁹ Sanchez *et al.* (2003). They find that port efficiency is a relevant determinant of a country's competitiveness.

²⁰ Hummels, Lugovskyy and Skiba (2009). They show that higher freight rates are charged for the carriage of higher value goods and for goods with lower import demand elasticity or to which higher tariffs are applied. They also find that higher rates are applied when there are fewer competitors on a given route.

²¹ Poulakidas and Joutz (2009) model the West Africa-United States Gulf spot tanker rates as a function of the West Texas intermediate crude oil spot prices, 3-months futures contract rates and the United States weekly petroleum inventories.

²² See also (2008). The OECD studies (OECD 2008 as well as OECD forthcoming) also examined maritime transport cost determinants other than fuel costs.

8. The effect of increased bunker costs on liner services has been investigated by Notteboom and Vernimmen (2008), who used a cost model to simulate the impact of bunker cost changes on the operational costs of liner services. The authors find that for a typical North Europe–East Asia loop bunker prices may have a significant impact on the costs per twenty-foot equivalent unit (TEU) even in the case of large post-panamax vessels.²³ Lundgren (1996), using data from 1950 to 1993, finds that for coal and grain trades from the United States to Europe, a 1 per cent increase in bunker rates leads to a 0.39 per cent increase in freight rates. Using this result, an estimated elasticity of 0.4 has been taken as a “rule of thumb” to address the impact of doubling in oil prices.²⁴ The study, however, did not investigate the impact of increased bunker fuel costs on container shipping which, in terms of value, today accounts for over 70 per cent of world trade.

9. There is a strand of literature that models dry bulk and tanker markets using structural modeling and estimation.²⁵ Tinbergen’s seminal contribution specified a two equation model which assumed demand as exogenous and equal to supply (Tinbergen, 1931). Supply was determined by the fleet size, costs (proxied by bunker prices) and the freight rate. As emphasized by Glen and Martin (2005), Tinbergen introduced the idea of a nonlinear supply curve, highly elastic to freight rates at low levels of capacity utilization and highly inelastic at high levels of capacity utilization. This implies that (at least in the short run) changes in demand would not alter freight levels much when the fleet is underutilized (flat segment of the supply curve), but would have big effects when the fleet is highly utilized (vertical segment).

10. The interaction of a generally inelastic demand curve for shipping and a generally nonlinear supply curve determines market freight rates.²⁶ It is worth noting in the tanker market, for instance, that the forces of supply and demand can make the relationship between the crude oil price and spot tanker rates ambiguous.²⁷ This is because there are two possible feedback mechanisms. First, a rise in the oil price is caused by a rise in oil demand. This generates an increase in the demand for oil transportation and results in a positive association. Second, a rise in the oil price might be caused by a reduction in the supply of oil. This implies a fall in the demand for oil transportation services and an expected fall in the spot price.²⁸ Finally, Hawdon (1978) proposes a model of the behaviour of annual average tanker spot rates, estimated for the period 1950–1973. He finds a long-run elasticity²⁹ of an exogenous shift in bunker costs on the rate index of 1.7 (the long-run elasticity is similar: 1.9).

²³ Post-Panamax or over-Panamax refers to large ships that can transit through the Panama Canal.

²⁴ Rubin and Tal (2005).

²⁵ For a survey, see Glen and Martin (2005).

²⁶ Beenstock and Vergottis (1993).

²⁷ This issue was discussed in the study by Glen and Martin (2005), which found that the effect of the growth in the real oil price on spot rate growth is negative and positive for the 250,000 dwt and the 130,000 dwt tanker vessels, respectively.

²⁸ Glen and Martin (2005).

²⁹ The elasticity of Y to X gives the percentage change in Y following a 1 per cent change in X. For percentage increases of more than 1 per cent, there is an approximation error.

C. METHODOLOGY AND RESULTS

I. Container freight rates

11. This section considers the effect of oil prices³⁰ on container freight rates along the three main East–West container routes, namely the transpacific, the transatlantic and Asia–Europe. While bulk cargo dominates world seaborne trade volumes, containerized trade, a fast-growing market segment is at the heart of globalized production and trade (growing by a factor of five between 1990 and 2008, at an average annual rate of about 10 per cent).³¹ Container trade is estimated to account for over 70 per cent of total trade in terms of value.³² Containerized goods are mostly manufactured goods, which tend to have higher value per volume ratios than bulk cargoes. Given their higher value, on average, transport costs on ad valorem basis matter less for higher value goods.

I.1. Model

12. To assess the effect of oil prices on container freight rates, the following model was constructed and estimated:

$$(1) \quad fre_{iqy} = \alpha + \lambda_i + \delta T_y + \beta_1 bre_{qy} + \beta_2 vol_{qy} + \beta_3 flow_{iy} + \beta_4 imb_{iy} + \beta_5 har_{qy} + \varepsilon_{iqy}$$

where:

- fre_{iqy} = average freight rate (expressed in United States dollars) charged by ocean carriers to ship TEUs on direction i in quarter q of year y ;
- bre_{qy} = price per barrel of crude oil-Brent in quarter q of year y ;³³
- vol_{qy} = standard deviation of the price per barrel of Crude Oil-Brent in quarter q of year y ;
- $flow_{iy}$ = flows of containers on direction i in year y , expressed in million TEU;
- imb_{iy} = measure of imbalance of container flows on direction i in year y ;
- har_{qy} = Harpex, index of charter rates on direction i in year y ;
- α = a constant;
- λ_i = direction fixed effects;
- T_y = time trend; and
- ε_{iqy} = stochastic error term.

³⁰ Brent oil prices and bunker fuel costs are used interchangeably given the strong degree of correlation between the two variables (coefficient of correlation = 0.98).

³¹ UNCTAD, based on Clarkson Shipping Review, spring 2009.

³² See UNCTAD Handbook of Statistics 2008, table 2.2.A for the value of manufactured goods traded globally. The 70 per cent share of containerized trade in total trade (in terms of value) is estimated under the assumption that all manufactured goods are transported by container. In 2009, the volume of container trade (in tons) amounted to about 27 per cent of global seaborne dry cargo trade and to about 17 per cent of total global seaborne trade.

³³ Brent crude oil prices are easily available on a daily frequency. As will be shown in the section “Robustness checks”, they are very highly correlated with bunker prices (coefficient of correlation = 0.98) and constitute a good proxy for the oil prices in the shipping industry.

13. The variables fre_{iqy} , bre_{qy} , vol_{qy} , $flow_{iy}$, imb_{iy} , har_{qy} are expressed in natural logarithms to estimate elasticities. Freight rates for both directions on the transpacific, Asia–Europe–Asia and the transatlantic result in a panel with six “individuals” (i.e. directions). The variable vol is included to test whether freight rates respond to fluctuations in oil prices, rather than (or in addition to) their level. A positive coefficient would imply that the larger the volatility of oil prices, the higher the freight rates. The variable $flow$ reflects the demand for container shipping services and, to some extent, measures the degree of economies of scale.³⁴ A negative coefficient on this variable would imply that, the larger the trade flows, the lower the transport cost per TEU.

14. Trade imbalances have long been considered as an important consideration, in particular for liner carriers. In the presence of trade imbalances, a portion of containers is shipped empty. The larger the imbalance the greater the empty container incidence and the more significant are the costs from related operational challenges (e.g. repositioning empty containers, cabotage restrictions and empty mileage).³⁵

15. The inclusion of the variable har is motivated by the fact that an estimated 40 per cent to 60 per cent of the liner shipping fleet operated by the main shipping lines is chartered-in (i.e. cost factor to consider by the operator when setting the rate).³⁶ This variable could also serve as a proxy for capital costs. Some existing studies have indeed estimated a positive impact of this cost element on the level of freight rates.³⁷ The present study estimates the correlation coefficient between the charter rates and freight rates at 0.176 (in levels). To ensure that we reflect the fact that a large share of the fleet operated is also owned as opposed to chartered in, the results of the regressions that include and exclude the Harpex index are both presented.

16. A theoretical foundation for estimating equation (1) can be found, for instance, in Micco and Serebrinsky (2006).³⁸ In their study, air transport freight prices are assumed to be equal to the marginal cost multiplied by the air shipping companies’ mark-up.³⁹ In logs, $p_{it} = mc_{it} + \mu_{it}$; where i is a route and t indexes time. Assuming (or deriving from a model in line with Hummels, Lugovskyy and Skiba, 2009),⁴⁰ the determinants of $mc(_)$ and of $\mu(_)$, one can derive a reduced-form equation for freight rates of the type estimated in (1). In other words, we are assuming that oil prices constitute a component of liners’ marginal costs and estimating their impact on the industry price (freight rates).

³⁴ The average ship size could not be used to describe economies of scale as this information was not available at route level. It is important to be careful with interpreting $flow$ as a direct measure of economies of scale, as it is only picking up time-series variation, not differences in scale across routes. Since direction-specific fixed effects are included, one might even expect a positive coefficient on $flow$, as time series variation in $flow$ should presumably move the equilibrium up the supply curve. In this case a negative coefficient could then be interpreted as evidence of strong economies of scale that counterbalance this scaling-up effect.

³⁵ See for instance Hummels (2009) as well as relevant literature cited in Behar and Venables (2010).

³⁶ Alphaliner’s website information, quoted by Cariou and Wolff (2006).

³⁷ Cariou and Wolff (2006).

³⁸ They estimate the importance of each of the factors that explain air transport costs using a standard reduced form approach.

³⁹ The reduced form approach is also the standard used to estimate the importance of each factor in maritime transport whereby maritime charges are assumed to be equal to the marginal cost multiplied by shipping companies’ markup. See for example, Clark, Dollar and Micco (2004). See also Micco and Pérez (2002).

⁴⁰ Hummels, Lugovskyy and Skiba (2009).

17. Obtaining reliable data constitutes an important challenge when examining transport costs, including in the maritime transport sector.⁴¹ Therefore, a few points are worth mentioning here. First, the nature of the data (intercontinental trade, aggregated over all products)⁴² does not allow for the use of other variables that have been shown in the literature to affect shipping costs. Any product- (or sector-) specific variable and the so-called connectivity measures⁴³ – which have been constructed at country– and at country-pair level, could not be included. The inclusion of fixed effects – which capture any unobservable characteristic that is specific to a particular direction – is likely to partially address the exclusion of connectivity measures and other variables like market structure in the shipping industry.⁴⁴ Any other individual, but not time-specific, parameter such as distance, could not be estimated and is therefore excluded from the estimated equation.⁴⁵ Finally, the time trend captures any unobservable shock that equally affects all trade directions (e.g., weather conditions, global income shocks, legislative changes to the maritime sector and the like).

⁴¹ Wilmsmeier and Martínez-Zarzoso (2010).

⁴² While containerized trade involves mainly manufactured goods, some bulk commodities such as agricultural goods are increasingly being carried in containers. According to *Containerisation International*, all rates are average rates of all commodities carried by major carriers and which could therefore include some bulk commodities.

⁴³ Marquez-Ramos *et al.* (2006).

⁴⁴ Fixed effects are time-invariant. If connectivity and other variables do not change much over time, fixed effects are likely to correct for their exclusion.

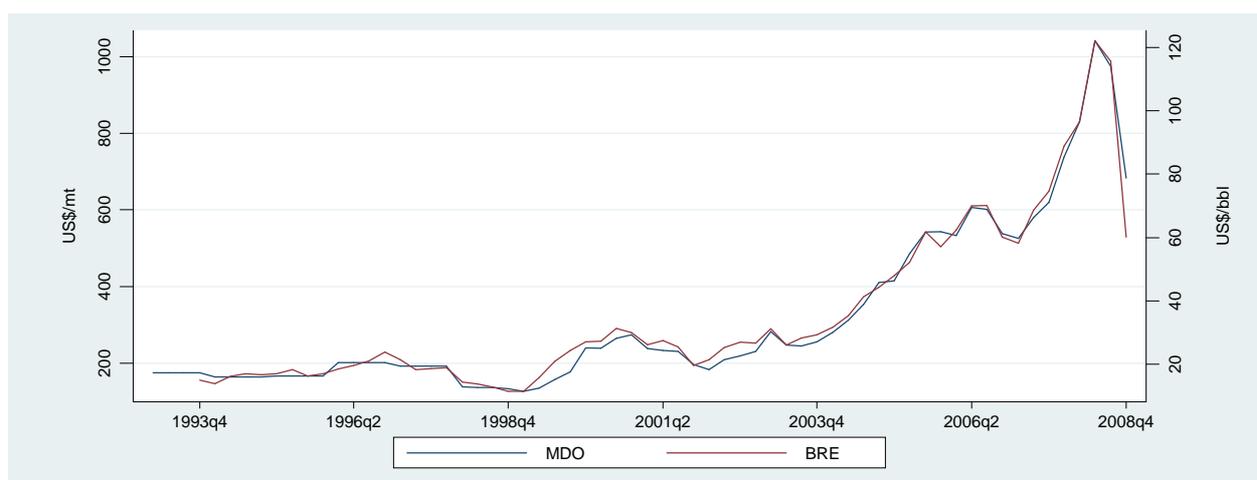
⁴⁵ Individual-specific variables would be dropped from the estimations due to collinearity.

I.2. Data⁴⁶

18. Data on freight rates are obtained from Containerisation International (CI) and cover the period 1993:Q4–2008:Q4. They reflect rates prevailing in both directions on the three major container trade routes (transpacific, Asia/Europe/Asia and transatlantic) and are expressed in \$/TEU and are all-in, i.e. including currency- and bunker-adjustment factors (CAFs and BAFs respectively), as well as terminal handling charges (THC) where gate/gate rates have been agreed, and inland haulage where full container load (FCL) rates have been agreed. All rates are average rates of all commodities carried by major carriers. Rates to and from the United States refer to the average of all three coasts.⁴⁷

19. Data on Brent crude oil⁴⁸ are expressed in current dollars per barrel (\$ pb) and are sourced from Thompson Datastream. The raw data contain five observations per week. We have used the quarterly average and standard deviation to compute BRE_{qy} and VOL_{qy} respectively.⁴⁹ Given the high degree of correlation between Brent oil prices and bunker fuel costs (correlation = 0.98) and data availability, Brent prices provide a good proxy for shipping fuel costs (see figure 1). As data used in figures displaying the evolution of oil prices are quarterly averages, the historical peak (\$147 pb) in crude oil prices recorded in July 2008 cannot be observed.

Figure 1. Brent crude oil prices and bunker prices (Marine Diesel Oil)



BRE: Brent crude oil prices, Datastream. MDO: Marine Diesel Oil, expressed as an average across the five ports of Rotterdam, Singapore, Tokyo, Los Angeles and Houston.

⁴⁶ Data reflecting the sharp fall in both oil prices and freight rates during the third quarter of 2008 could not be used in the regression analysis, as relevant trade data covering that period was not yet available for the purposes of this study.

⁴⁷ It should be noted that 80 per cent of trade is carried out through confidential service contracts. According to *Containerisation International*, their data on freight rates include all cargo and represent the actual rates achieved by ocean carriers. Indexes published by the European Liner Affairs Association (ELAA) also cover all cargo.

⁴⁸ Brent oil prices are used as opposed to other measures such as West Texas Intermediate (WTI). Notice, however, that the correlation between WTI and Brent is equal to 0.994 (WTI data can be found at <http://tonto.eia.doe.gov/dnav/pet/hist/rwtcd.htm>); therefore the use of one or the other indicator should not be a concern.

⁴⁹ vol_{qy} is computed as $\ln(1+sd(BRE))$.

20. Data on container flows are from UNCTAD's *Review of Maritime Transport* (various issues). They are available on an annual basis, for the period 1995–2007 in both directions on the three major seaborne trade routes. The measure of imbalance is simply computed as:

$$imb = \ln\left(1 + \frac{FLOW_{jk} - FLOW_{kj}}{FLOW_{jk} + FLOW_{kj}}\right)$$

where j and k are the two ends of a given route i .⁵⁰

21. Finally, HAR is the HARPEX charter rates index computed by Harper Petersen & Co.⁵¹ The index is recorded weekly with the average over each quarter being used in the estimations.

I. 3. Time series

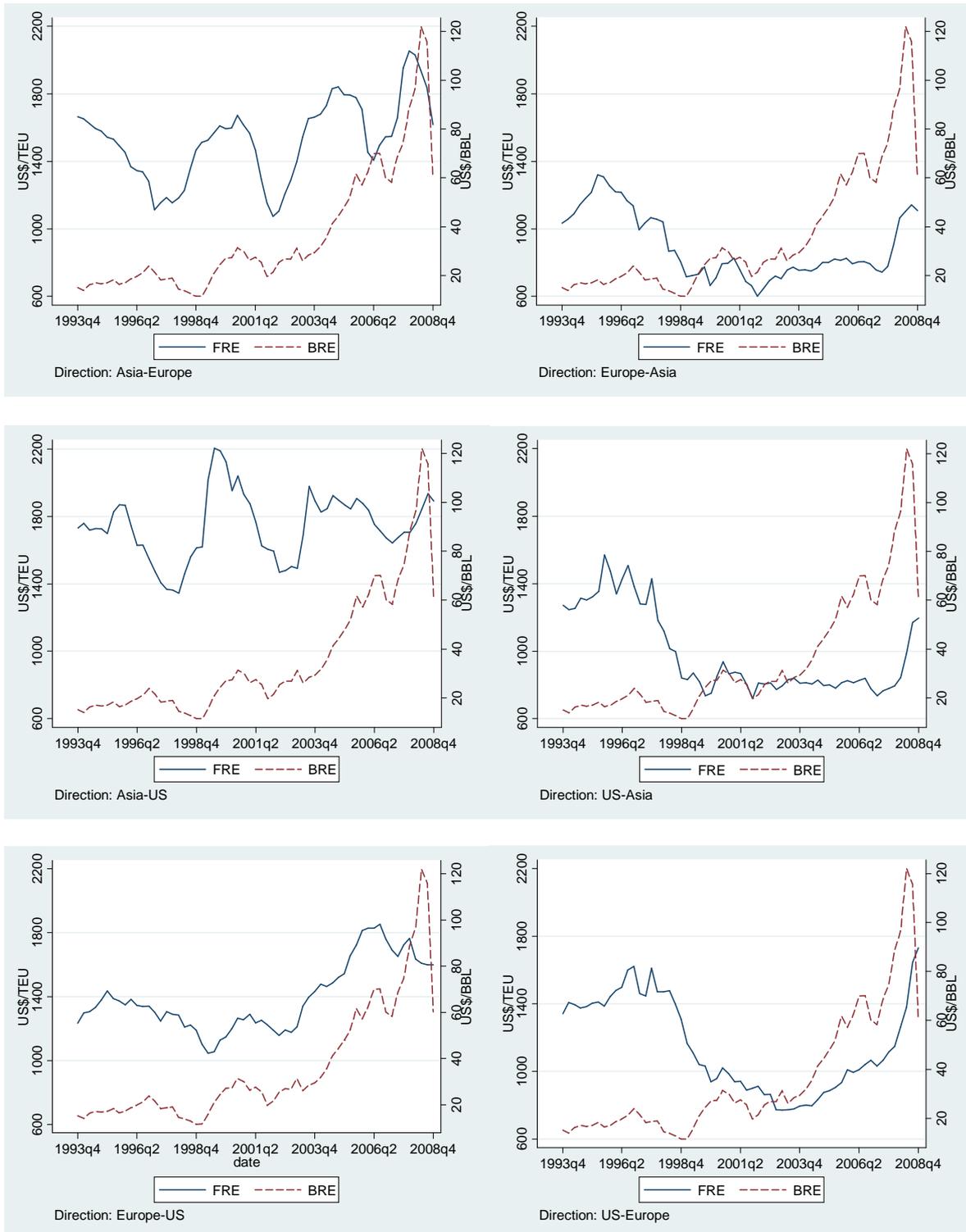
22. Figure 2 plots the time series FRE (freight rates) and BRE (Brent oil prices), by container route and by direction. The variables are expressed in levels, and the respective scale for FRE and BRE is on the left and right axis of each figure. Each figure plots one direction on a container trade route. There is a considerable degree of variability in FRE (blue, continuous line), while BRE (red, dashed line) is quite stable until 2004, and then trends upward.

23. The time-series of BRE seems to follow two distinct patterns: one where oil prices are relatively stable and slowly rising followed by one where oil prices are sharply rising and more volatile. Freight rates, on the other hand, exhibit wide fluctuations, and no distinct pattern emerges. On the transpacific route, freight rates are systematically higher when the United States is the importer. The transpacific route, in particular, is marked by trade imbalances (the volume of containerized trade from Asia to the United States is always larger than the volume of containerized trade from United States to Asia). This suggests that trade imbalances are likely to be a more significant factor than oil prices in explaining freight rates differentials, because differences in freight rates seem to be systematically related to trade imbalances. Finally, it should be noted that given the use of quarterly averages the peak for oil prices in the figure is around \$120 instead of the historical peak of \$147 recorded in July 2008.

⁵⁰ Uppercase variables are expressed in levels. Since $IMB = (FLOW_{jk} - FLOW_{kj}) / (FLOW_{jk} + FLOW_{kj})$ is bounded between -1 and 1, adding 1 to each observation before taking logs avoids any loss of observations.

⁵¹ We wish to thank Christian Mueller of Harper Petersen & Co. for kindly providing the time series (since 1986) for the HARPEX index.

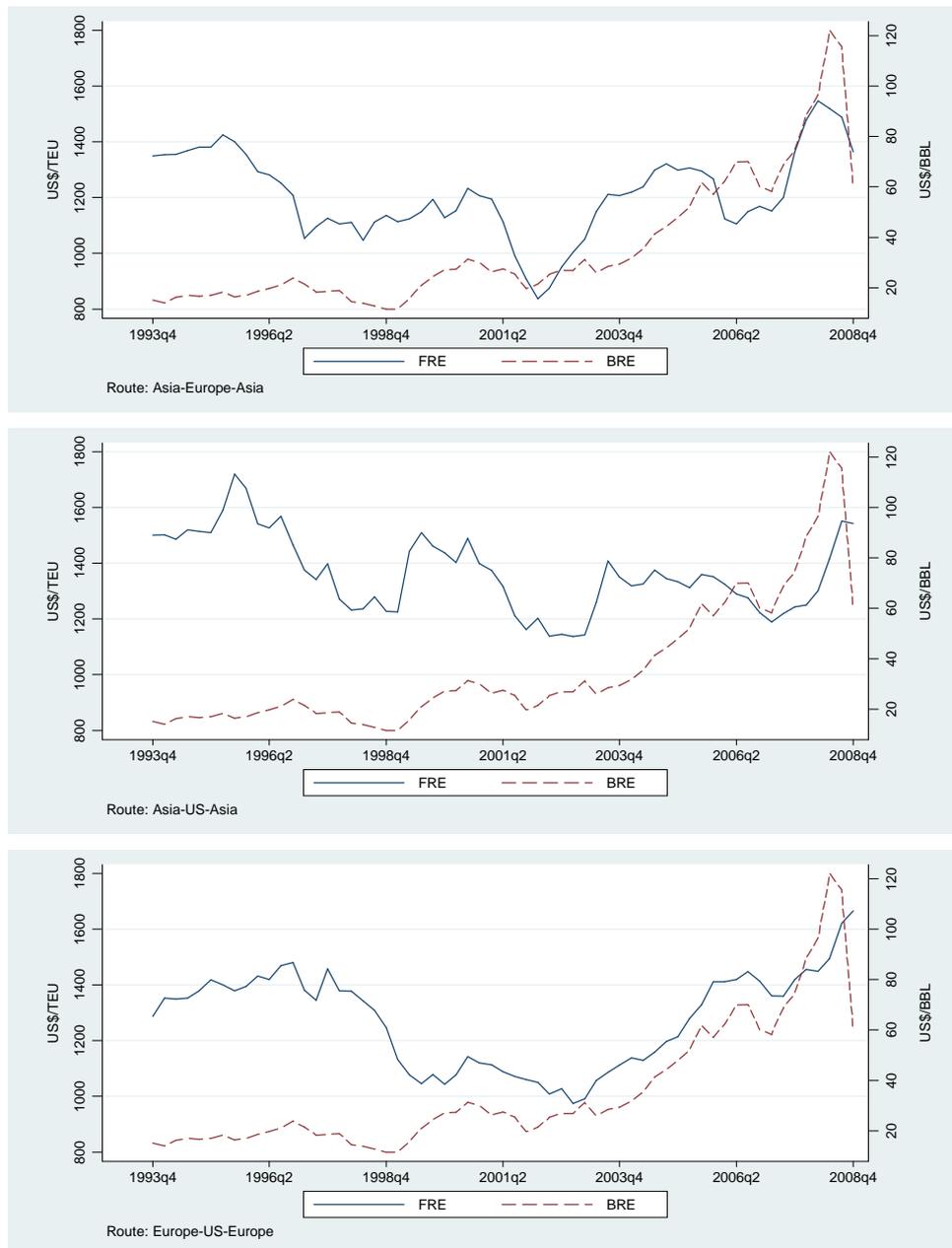
Figure 2. Brent crude oil prices and container freight rates on the main East-West container routes (by direction)



BRE: Brent oil prices, Datastream. FRE: Freight rates, Containerisation International (CI).

24. Figure 3 plots Brent oil prices vs. freight rates, aggregated over each container route. Assuming that each liner operates in both directions, the average freight rate on a route can be taken as a proxy for viability/profitability of the route from the perspective of a ship-operator. Again, it is difficult to discern any clear pattern: in periods of relatively stable oil prices, average freight rates per route have gone down, but in periods of rising oil prices average freight rates per route have experienced wide fluctuations. The only route where one can see a clear co-movement between average freight rates and oil prices is the Europe–United States–Europe transatlantic route, where rising oil prices have been matched by rising average freight rates.

Figure 3. Crude oil prices and container freight rates on the main East-West container routes (by route)



BRE: Brent oil prices, Datastream. FRE: Freight rates, Containerisation International (CI).

I.4. Estimation results⁵²

25. The results of the baseline model are presented in column (1) of table 1.⁵³ Since all variables are in natural logarithms, the point estimates are interpreted as elasticities. The estimated elasticity of container freight rates to Brent crude oil prices is positive and statistically significant in all models. Consider first the OLS (ordinary least squares) estimations (respectively, columns 1 and 3 for the model with or without *har*).⁵⁴ The point estimate for the OLS regression that includes *har* is equal to 0.137, that is, a 1 per cent increase in Brent crude oil prices leads to an increase of 0.137 per cent in freight rates. The point estimate for the OLS regression without *har* is significantly higher, equal to 0.291, while the within-R squared is slightly lower (0.45 versus 0.50).

26. With the OLS, the estimated elasticities of *vol* and *flow* are small and not statistically significant. If we were to take these results at face value, this would suggest that neither the volatility of oil prices nor the volume of trade has an impact on freight rates. The coefficient of the variable measuring trade imbalances is positive and significant, with an estimated elasticity of 1.365 (including *har*) and 1.373 (excluding *har*). Freight rates seem to respond more than one-to-one (in percentage terms) to trade imbalances. Finally, the point estimate on *har* (column 1) is equal to 0.192, suggesting, as expected, a positive effect of charter rates on freight rates, albeit not very large.

27. These results, however, do not take into account the potential endogeneity of trade volumes (variable *flow*).⁵⁵ It might be that the direction of causality runs from container freight rates to trade flows (reverse causality). As it is important to factor out the effect of trade on freight rates, an instrument is needed for trade, which is correlated with trade, but uncorrelated with freight rates. For each trade direction, the product of the two regions' GDPs (in constant United States dollars, base year 2000) is used as such an instrument.⁵⁶ (The validity of the instrument is discussed in section 1.4.1 below).

⁵² The elasticity is the percentage increase in the dependent variable caused by a 1 per cent increase in the explanatory variable. For percentage increases of more than 1 per cent, there is an approximation error. In the example, a 10 per cent increase is considered. As a result, an extrapolation from estimated elasticities beyond 1 per cent is subject to an approximation error.

⁵³ In this and subsequent regression handouts, the coefficients on the constant and the time trend are not reported since they have no economic interpretation. The inclusion of a constant term is standard practice. Removing the constant from the model could lead to incorrect standard errors if the data were demeaned before the regression, while adding a constant does not do any harm. Note that in fixed effects estimations the intercept is the average value of the fixed effects. *** denotes that the estimated coefficient is significant at the 1 per cent confidence level; ** denotes significance at the 5 per cent confidence level; * denotes significance at the 10 per cent confidence level. In the tables that report the coefficient estimates, the more stars, the higher the level of statistical significance of the results.

⁵⁴ In the OLS estimations two-way clustered standard errors is used (cluster variables: route, quarter) to take into account the fact that some variables (*flow*, *imb*) vary only within routes and years, but not within each quarter, while some others (*bre*, *har*) vary within quarters, but not within routes. IV-GMM regressions use Huber-White robust standard errors, because it was not possible to use two-ways clustering in this case. Huber-White robust standard errors are robust to arbitrary patterns of heteroskedasticity and autocorrelation.

⁵⁵ Endogeneity tests performed confirmed that *flow* cannot be treated as exogenous (endogeneity test statistics 4.906, p-value 0.027).

⁵⁶ Annual data from UNCTAD Globstat are used. For Asia, use is made of the regional aggregate ASEAN + China, Japan and Republic of Korea. It might be argued that a better instrument, and indeed one that is widely used in empirical literature, could be obtained using the prediction of a gravity equation that explains trade with distance,

Table 1. Estimation of equation (1)

	(1) OLS ^a	(2) IV-GMM ^b	(3) OLS ^a	(4) IV-GMM ^b
Bre	0.137** (0.0576)	0.190*** (0.0526)	0.291*** (0.0782)	0.360*** (0.0439)
Vol	-0.0574 (0.0409)	-0.0726** (0.0317)	-0.0509 (0.0393)	-0.0721** (0.0340)
Flow	0.0285 (0.0834)	-0.216* (0.128)	0.0198 (0.0959)	-0.317** (0.130)
Imb	1.365*** (0.398)	1.897*** (0.329)	1.373*** (0.461)	2.105*** (0.352)
Har	0.192*** (0.0615)	0.188*** (0.0351)		
Observations	312	312	312	312
R-squared ^c	0.5		0.45	

^a Two-way clustered standard errors in parentheses, cluster variables: (route, quarter).

^b Huber-White robust standard errors in parentheses.

^c Within R-Squared.

*** p<0.01, ** p<0.05, * p<0.1

28. It is therefore more reliable to consider the results of the instrumental variable estimations (IV-GMM) presented in columns 2 and 4 of table 1 (respectively for the specification with and without *har*).⁵⁷ The first thing to notice is that the elasticity of freight rates to oil prices is larger than in the OLS estimations. The elasticity is equal to 0.19 in the regression with *har*, and to 0.36 in the regression without *har*. An elasticity of 0.19 is close to the upper bound of the estimates by the OECD (forthcoming)⁵⁸ – although a direct comparison between the two studies is difficult since the OECD has a detailed dataset which allows for product-level variables such as the elasticity of substitution and tariffs to be included. Again, bearing in mind differences in datasets and methodologies, the upper bound of the estimated elasticity (0.36) is also in line with the “rule of thumb” of an elasticity of 0.39 for 1 per cent increase in bunker rates.⁵⁹ These estimates are also in line with results obtained by Hummels (2007) who found the ad valorem ocean freight costs to be increasing in fuel costs with elasticities ranging between 0.327 and 0.232. In contrast, the estimated elasticities diverge from those estimated by Mirza and Zitouna (2009) and which indicate a limited effect of oil prices on transport.

population, language, land border, land area and landlocked status. Such an IV approach, though common in most applications, could not be adopted here. In the case of the present study, use is made of interregional flows. Yet, the gravity-type variables as noted are used for inter-national trade flows. In other words, it would be possible to use an approach of instrumenting for trade using the predicted values of a gravity approach only if data were disaggregated by nation and not aggregated by trading region.

⁵⁷ GMM stands for “Generalized Method of Moments”.

⁵⁸ OECD (forthcoming).

⁵⁹ Lundgren (1996).

29. The IV-GMM regressions yield a negative and statistically significant impact of trade volumes on freight rates. If the instrument is valid, as argued below, the estimated elasticities (-0.216 and -0.317, respectively) can be interpreted as *causal* effects of trade volumes on freight rates, therefore an increase in the volume of shipped containers leads to a decrease of freight rates for containers. The negative sign indicates that there are economies of scale in containerized shipping whereby shipping costs per TEU are lower, the higher trade volumes.⁶⁰ An estimated elasticity of -0.317 (column 4) is indeed quite substantial, because of large variance in container flows. By way of example, shipping 1.1 million TEU rather than 1 million would reduce freight rates by approximately 3.2 percent.⁶¹ Finally, the elasticity of *har* is estimated to be similar to the OLS estimation (0.188).

30. In addition to the logarithmic regressions, model (1) is also estimated in levels. The results are found to be qualitatively similar to the results of the estimation in logarithms both in terms of sign and statistical significance.

I.4.1. Validity of the instrument

31. An instrument is valid if correlated with the instrumented explanatory variable (container trade volumes), and uncorrelated with the dependent variable (container freight rates). For each trade route, the product of the GDP of two relevant regions has been used as an instrument for trade volumes. This variable is found to be hardly correlated with freight rates since the sample correlation coefficient between the instrument and freight rates (in logs) is equal to -0.08. By contrast, in the first stage regressions, the instrument is found to be highly correlated with trade volumes since the regressions results in a point estimate of 3.11 (robust standard error 0.44), indicating that there is a positive and significant correlation between the instrument and trade volumes. Taking into account these results, the instrument is considered to be valid and the estimated elasticity of freight rates to trade volumes in the IV-GMM regressions of table 1 can be interpreted as causal effects.

I.4.2. Oil prices, freight rates and oil price volatility

32. As shown in figure 2 above, the series BRE seems to exhibit two distinct trends which, at the outset, indicate the presence of a structural break.⁶² Until 2004, Brent prices were relatively stable or slowly rising, without major spikes (to around \$40 pb). Starting in 2004, prices increased sharply to reach more than \$120 pb before collapsing in the aftermath of the global credit and economic crises that unfolded in mid-2008.

⁶⁰ See for instance Hummels (2009). See also relevant literature cited by Behar and Venables (2010).

⁶¹ The elasticity is the percentage increase in the dependent variable caused by a 1 per cent increase in the explanatory variable. For percentage increases of more than 1 per cent, there is an approximation error. In the example, we consider a 10 per cent increase in trade flows, so the estimated increase in freight rates of 3.2 per cent is subject to an approximation error.

⁶² A simple Clemente-Montanes structural break test indeed confirms the presence of a structural break in 2004:Q1 (p-value 0.060). The Clemente-Montanes test examines whether a time series has distinct trends, separated by “structural breaks”.

33. In order to investigate the hypothesis that the relationship between freight rates and oil prices may be significantly different in periods of relatively stable oil prices than in periods of upward trending oil prices, the baseline model (1) is augmented with a dummy variable *SB*. The dummy equals to one for observations starting in the first quarter of 2004, and zero otherwise. The augmented model to estimate is as follows:

(2)

$$fre_{iqy} = \alpha + \lambda_i + \delta T_y + \beta_1 bre_{qy} + \beta_2 vol_{qy} + \beta_3 flow_{iy} + \beta_4 imb_{iy} + \beta_5 har_{qy} + \beta_6 SB_{qy} + \beta_7 INT_SB_{qy} + \varepsilon_{iqy}$$

where the variable *INT_SB* is equal to the product of *bre* and the dummy variable *SB*. Since by construction *SB* is equal to one if $t > 2004:Q1$, zero otherwise, the estimated elasticity of *bre* is equal to $(\beta_1 + \beta_7)$ if $t > 2004:Q1$, and to β_1 otherwise.⁶³

Table 2. Estimation of equation (2)

	(1) OLS ^a	(2) IV-GMM ^b	(3) OLS ^a	(4) IV-GMM ^b
Bre	0.00288 (0.0381)	0.0605 (0.0583)	0.145*** (0.0472)	0.215*** (0.0486)
SB	-1.071** (0.468)	-1.239*** (0.311)	-0.356 (0.450)	-0.549** (0.273)
INT_SB	0.295** (0.137)	0.338*** (0.0777)	0.138 (0.132)	0.188*** (0.0709)
Vol	-0.0465 (0.0358)	-0.0660** (0.0315)	-0.0526 (0.0409)	-0.0759** (0.0338)
Flow	0.00917 (0.0672)	-0.337*** (0.120)	0.0106 (0.0709)	-0.402*** (0.125)
Imb	1.406*** (0.351)	2.157*** (0.310)	1.399*** (0.380)	2.296*** (0.334)
Har	0.209*** (0.0679)	0.211*** (0.0466)		
Observations	312	312	312	312
R-squared ^c	0.54		0.50	

^a Two-way clustered standard errors in parentheses, cluster variables: (route, quarter).

^b Huber-White robust standard errors in parentheses.

^c Within R-Squared.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

34. Considering only IV-GMM regressions (which correct for the endogeneity of *flow*), the estimated elasticity of freight rates to oil prices is equal to $(0.060 + 0.338 = 0.398)$ in the regression of column 2, and to $(0.215 + 0.188 = 0.403)$ in regression of column 4. This is slightly higher than the elasticities estimated for the baseline model (1), suggesting that the effect of oil prices on freight rates is indeed slightly higher after the sharp increase in oil prices since 2004. In other words, the higher the oil prices the more freight rates are affected/react. It could be that ship-owners may be able to absorb increases in oil prices for smaller oil price increases but tend

⁶³ A different intercept is also allowed for and is equal to $(\alpha + \beta_6)$ if $Brent > 60$, and to α otherwise.

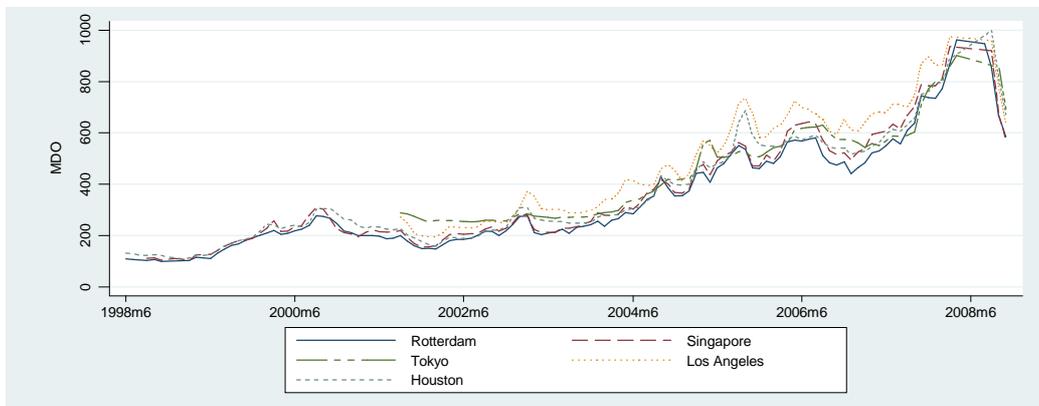
to pass on the cost to shippers as the oil prices increase further (i.e. through bunker adjustment cost factor).

I.4.3. Robustness checks

35. Brent oil prices are the same for every route and direction. However, bunker prices vary depending on the bunkering port. To reflect this variability, data has been collected to construct route-specific measures of bunker prices.⁶⁴ Data pertaining to a selection of ports for the period 1993–1999 has been used for the purposes of this analysis. Relevant ports include Rotterdam for Europe, Los Angeles for the United States (on the transpacific route), Houston for the United States (transatlantic route), and an unweighted average between Tokyo and Singapore for Asia.⁶⁵

36. As shown in figure 4, the various bunkering prices are strongly correlated. Nevertheless, the marked co-movement among bunker prices in the different bunkering ports masks important differences in their levels (see table 3). The bunker market is price-sensitive, with bunker rates fluctuating with fluctuations in crude oil prices and where bunkering decisions being determined by price differences arising from different fiscal policies across countries. The average marine diesel bunker prices over the last decade ranged from 343.6 in Rotterdam to 493.7 in Los Angeles. *Ceteris paribus*, assuming an elasticity of 0.3, if bunker prices are 43 per cent lower as is the case in Rotterdam vis-à-vis Los Angeles, container shipping rates for cargo shipped from Rotterdam instead of Los Angeles—depending on distance travelled—are estimated to be 13 per cent lower.

Figure 4. Bunker fuel prices (MDO) across select major bunkering ports



Source: Bunkerworld.

⁶⁴Special thanks to Mr. David Post of Bunkerworld for providing the monthly data (June 1998 and November 2008) on prices for six types of bunker fuels (MDO type) for 75 ports in Asia, the United States and Europe.

⁶⁵Data before 1998 are from *Clarkson's Shipping Review Outlook*, various issues, at annual frequency.

Table 3. Average bunker fuel prices at select bunkering ports (1998–2008)

Bunkering port	Marine Diesel Oil (MDO)
Rotterdam	343.6
Houston	355.9
Singapore	357.4
Fujairah	373.8
Tokyo	448.8
Los Angeles	493.7

Source: Bunkerworld.

37. For the purposes of this analysis, the bunker price at the origin of the ship's journey is considered to be the relevant bunker price. Model (1) is modified by replacing Brent oil prices (BRE) by marine diesel oil prices (*mdo*). The measure of volatility of bunker prices has been excluded.⁶⁶ Bearing in mind the above, the following model was estimated:

$$(3) \quad fre_{iqy} = \alpha + \lambda_i + \delta T_y + \beta_1 mdo_{iqy} + \beta_2 flow_{iy} + \beta_3 imb_{iy} + \beta_4 har_{qy} + \varepsilon_{iqy}$$

38. As shown in table 4, the results with *mdo* are qualitatively and quantitatively similar to the ones obtained with Brent crude oil prices (see columns 2 and 4 of table 1).

Table 4. Estimation of equation (3), with bunker prices (MDO)

	(1) OLS ^a	(2) IV-GMM ^b	(3) OLS ^a	(4) IV-GMM ^b
Mdo	0.105 (0.102)	0.175*** (0.0555)	0.274*** (0.0875)	0.342*** (0.0393)
Flow	0.0374 (0.0969)	-0.258* (0.137)	0.0147 (0.0981)	-0.338** (0.137)
Imb	1.384*** (0.449)	2.052*** (0.364)	1.488*** (0.439)	2.281*** (0.373)
Har	0.191*** (0.0669)	0.175*** (0.0388)		
Observations	312	312	312	312
R-squared ^c	0.50		0.45	

^a Two-way clustered standard errors in parentheses, cluster variables: (route, quarter).

^b Huber-White robust standard errors in parentheses.

^c Within R-Squared.

*** p<0.01, ** p<0.05, * p<0.1

39. As expected, the high degree of correlation of almost one-to one (correlation = 0.98 in our sample) between Brent crude oil prices and bunker fuel prices makes oil prices a good proxy for ships' fuel costs. Worth noting is the fact that the results remain unaffected when freight rates

⁶⁶ To avoid losing information, a measure of the volatility of bunker prices has been excluded. This is because volatility on quarterly basis cannot be computed when using annual data for 1993–1999 period.

per nautical mile are used as the dependent variable.⁶⁷ The estimated elasticities can also be interpreted as the percentage change in freight rates per nautical mile following a 1 per cent increase in oil prices. Similarly, nothing changes when using real variables, i.e. when taking into account inflation (variables expressed in current dollars are deflated using the United States consumer price index (CPI)).⁶⁸

⁶⁷ Distance is calculated from the World Ports Distances Calculator available at <http://www.distances.com/>. We use the following representative ports: for Europe-Asia: Rotterdam to Hong Kong, China; for Asia-United States: Hong Kong, China to Los Angeles; for Europe-United States: Rotterdam to New York. The results are available upon request.

⁶⁸ Data on the United States CPI can be found on the website of the United States Bureau of Labor Statistics, <http://www.bls.gov/CPI>.

II. Iron ore freight rates⁶⁹

40. This section extends the analysis to dry bulk trade by focusing in particular on iron ore, a major bulk commodity that has been the mainstay of a boom in global trade over the past few years.⁷⁰ In 2008, iron ore accounted for over 10 per cent of world trade in volume terms with Australia and Brazil together being responsible for over two thirds of world iron ore exports. China is the main iron ore importer reflecting its booming steel production sector. Other major importers included Japan, Western Europe, and, to a lesser extent, some Asian countries such as the Republic of Korea, Taiwan Province of China and Malaysia. Seaborne trade of iron ore is therefore quite concentrated on a few selected routes and countries.

II.1. Model

41. To assess the effect of oil prices on iron ore spot freight rates, the following models for the eight commercial routes for which data are available was constructed and estimated:

$$(4) \quad fre_{imy} = \lambda_i + \delta T_{my} + \beta_1 bre_{my} + \beta_1 vol_{my} + \beta_3 price_{iy} + \beta_4 trade_{iy} + \beta_5 bdi_{my} + \varepsilon_{iqy}$$

$$(5) \quad fre_{imy} = \lambda_i + \delta T_{my} + \beta_1 bre_{my} + \beta_1 vol_{my} + \beta_3 trade_{iy} + \beta_4 bdi_{my} + \varepsilon_{iqy}$$

where:

- fre_{imy} = representative spot freight rate (expressed \$/ton) on route i in month m of year y ;
- bre_{my} = price per barrel of Brent crude oil in month m of year y ;
- vol_{my} = standard deviation of the price per barrel of Brent crude oil in month m of year y ;
- $price_{iy}$ = iron ore price, expressed in \$/ton, on route i in year y ;⁷¹
- $trade_{iy}$ = trade volume (million tons) of iron ore on route i in year y ;
- bdi_{my} = Baltic Dry Index (BDI);
- λ_i = route fixed effect;
- T_{my} = time trend; and,
- ε_{iqy} = stochastic error term.

42. Model (5) is a variation of model (4) and excludes the price of iron ore from the set of explanatory variables. As relevant data only goes back to 1999, controlling for iron ore prices would result in missing out on the number of observations and losing information. Additionally, model (5) allows for comparisons to be made with the results of estimations relating to tanker trade in section III of the present paper.

⁶⁹ Data on freight rates as sourced from Drewry and as published in UNCTAD's *Iron Ore Statistics 2008*. We wish to thank Mr. Rahul Sharan and Ms. Susan Oatway for kindly providing access to data and providing a breakdown of the spot iron ore freights. Spot iron ore freight rates as published by Drewry and in UNCTAD's *Iron Ore Statistics 2008* take into account the following costs: distance, fuel costs, sea margin (i.e. assumed delays at sea during transit), port costs, commission (i.e. address and brokers), ballast voyage charges and charter rates.

⁷⁰ For further information see UNCTAD, 2009(b): chapter 1.

⁷¹ The price is computed from raw data expressed in United States cents per 1 per cent Fe per ton, using a conversion factor equal to 0.64.

II.2. Data⁷²

43. Data on iron ore freight rates and prices are sourced from UNCTAD's *Iron Ore Statistics*, published in September 2008 and cover the period 1993:M1–2008:M4 (with some missing observations). The rates relate to eight maritime routes, namely Australia–China, Australia–Europe, Australia–Japan, Brazil–China, Brazil–Europe, Brazil–Japan, Canada–Europe, Norway–Europe, South Africa–China and South Africa–Europe. Annual trade data are sourced from United Nations COMTRADE. The (monthly) time series of the Baltic dry index is from Thomson Datastream.

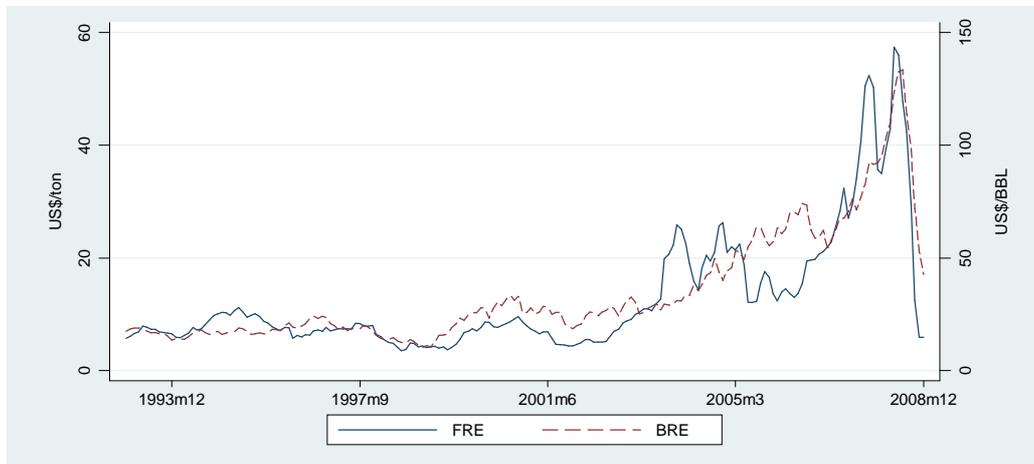
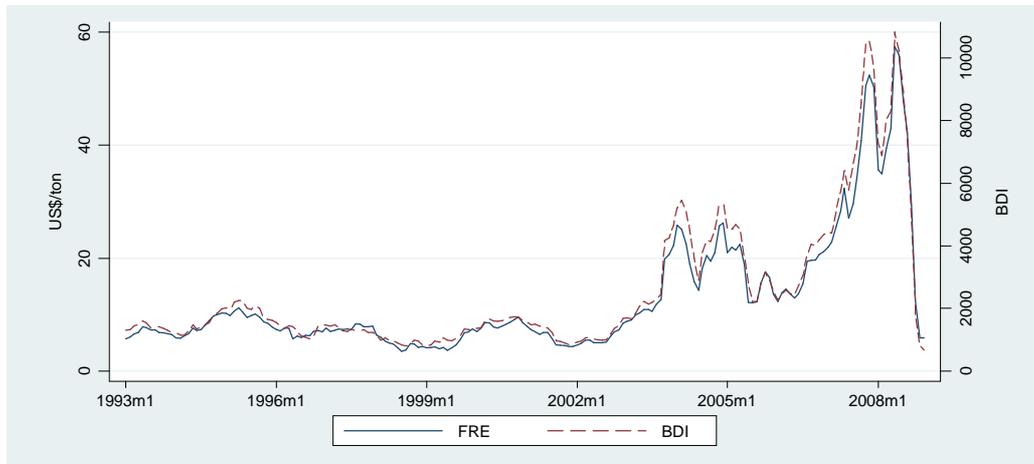
II.3. Time series

44. Figure 5 shows the movement of iron ore freight rates and the BDI, the Brent oil prices as well as the price of iron ore. According to the chart, freight rates and the BDI are moving in tandem suggesting a high degree of correlation. This is to be expected since the BDI is a compendium of spot voyage charter rates for a mixture of bulk carriers over different routes and could therefore serve as a proxy for iron ore freight rates. To ensure that any bias in coefficients that may result from regressing iron freight rates on its proxy is taken into account, an equation that excludes the *bdi* from the set of the explanatory variables has also been estimated.

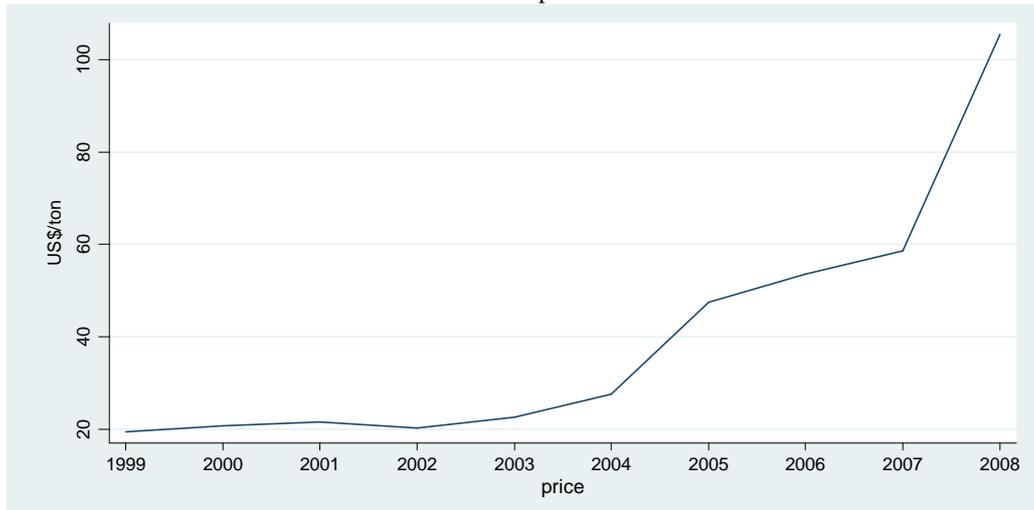
45. The marked drop in iron freight rates as well as in the value of the BDI both recorded in the second half of 2008 is worth noting. The BDI dropped from an historical peak of 10,800 in May 2008 to 676 in December 2008, a cumulative drop of more than 90 per cent. The chart also highlights the overall matched movements between iron ore freight rates and Brent oil prices, including the dramatic dive at the end of 2008. Driven mainly by increased and sustained demand in emerging dynamic developing countries in Asia, especially China, iron prices have increased substantially since 2004 along the same trend of Brent crude oil prices. In all evidence, the global credit crunch and the economic downturn have a role to play in the sudden slump in the dry bulk commodity trade.

⁷² Data reflecting the sharp fall in both oil prices and freight rates during the third quarter of 2008 could not be used in the regression analysis, as relevant trade data covering that period was not yet available for the purposes of this study.

Figure 5. Iron ore freight rates and prices, Baltic Dry Index (BDI) and Brent crude oil prices



Iron ore prices



BDI: Baltic Dry Index, Datastream. FRE: Freight rates and iron ore prices are obtained from UNCTAD *Iron Ore Statistics*, September 2008.

II.4 Estimation results⁷³

46. The OLS and IV-GMM estimates of model (4) are presented in table 5 below. To take into account the endogeneity problem, GDP of the importer (constant United States dollars, base year 2000)⁷⁴ has been used as an instrument for *trade* in the IV-GMM estimation. The validity of this instrument is confirmed by the results of first stage regressions, where the elasticity of the instrument to trade is estimated at 2.35 (standard error 0.105).

Table 5. Estimation of equation (4)

	(1) OLS ^a	(2) IV-GMM ^b	(3) OLS ^a	(4) IV-GMM ^b
Bre	0.149*** (0.0515)	0.149*** (0.0262)	1.063*** (0.259)	1.051*** (0.0521)
Vol	0.0200*** (0.00675)	0.0202 (0.0138)	0.00189 (0.0735)	0.00451 (0.0434)
Price	-0.0409 (0.0332)	-0.0442* (0.0227)	-0.145 (0.273)	-0.179*** (0.0613)
Trade	0.107** (0.0429)	0.120*** (0.0173)	0.281*** (0.0460)	0.424*** (0.0526)
Bdi	0.888*** (0.0235)	0.886*** (0.00910)		
Observations	936	936	936	936
R-squared ^c	0.97	.	0.62	.

^a Two-way clustered standard errors in parentheses, cluster variables: (route, quarter).

^b Huber-White robust standard errors in parentheses.

^c Within R-Squared.

*** p<0.01, ** p<0.05, * p<0.1

47. The effect of Brent crude oil prices on iron ore freight rates is estimated to be positive and statistically significant. Considering the regressions that exclude *bdi* (columns 3 and 4), relevant estimated coefficients are much larger than the corresponding coefficients in the regressions run in the context of containerized trade.⁷⁵ In other words, the elasticity of freight rates to oil prices seems to be significantly larger when considering a select bulk commodity than in container trade. It is interesting to note that, unlike the container trade, where the HARPEX index had little impact, including or excluding the BDI may have a large impact on iron ore freight rates. Excluding the BDI from the equation confers a larger explanatory power to Brent oil prices/bunker prices.⁷⁶

⁷³ The elasticity is the percentage increase in the dependent variable caused by a 1 per cent increase in the explanatory variable. For percentage increases of more than 1 per cent, there is an approximation error. In the example, a 10 per cent increase is considered. As a result, an extrapolation from estimated elasticities beyond 1 per cent is subject to an approximation error.

⁷⁴ UNCTAD Globstat data.

⁷⁵ An elasticity of 1 implies a 1 per cent change in iron ore freight rates following a 1 per cent increase in oil prices.

⁷⁶ Bulk and liner shipping are however very different in terms of market structure and elasticity comparisons should be attempted with extreme care if legitimate at all.

48. The estimated coefficient of the measure of volatility (*vol*) is small and not statistically significant (except in column 1), suggesting that oil price volatility has limited impact on iron ore freight rates, after taking into account the level of oil prices. Iron ore freight rates are found to be negatively correlated with iron ore prices. After correcting for a potential endogeneity problem, the coefficient for the value of iron ore (*price*) is estimated to be negative and statistically significant (-0.044 and -0.179), suggesting that a 10 per cent increase in iron ore prices will lead to around 0.4 per cent to 1.8 per cent drop in freight rates (columns 2 and 4). This result differs from results of other studies that have estimated the coefficient for the value/weight ratios to be positively correlated with freight rates,⁷⁷ suggesting that the higher the value of the goods shipped, the higher the transport costs. One reason for the different results could be data-related. (see discussion below in para. 70).

49. The volume of iron ore trade (*trade*) is positively correlated with freight rates and statistically significant (0.120 to 0.424) as shown in columns 2 and 4, respectively. This result is expected given the major boom experienced in the dry bulk sector over the study period and the related scaling-up effect.⁷⁸ The rapid economic growth and the intensified industrialisation process of dynamic emerging developing countries such as China have raised demand for raw materials including iron ore. Increased demand combined with an inelastic bulker capacity supply, at least in the short term, may push iron ore freight rates upwards.

⁷⁷ See for example, OECD (forthcoming).

⁷⁸ A scaling-up effect refers to an increased demand that shifts the equilibrium up the supply curve. The result is consistent with some existing literature. See for example Tsolakis (2005).

50. Table 6 presents the OLS and IV-GMM estimates of model (5):

Table 6. Estimation of equation (5)

	(1) OLS ^a	(2) IV-GMM ^b	(3) OLS ^a	(4) IV-GMM ^b
Bre	0.0936*** (0.0252)	0.0935*** (0.0126)	0.872*** (0.0575)	0.888*** (0.0225)
Vol	0.0210 (0.0170)	0.0210 (0.0133)	-0.0980 (0.0787)	-0.100*** (0.0357)
Trade	0.0729*** (0.0137)	0.0739*** (0.0112)	0.154*** (0.0562)	0.0826*** (0.0315)
Bdi	0.890*** (0.0254)	0.890*** (0.00826)		
Observations	1380	1380	1380	1380
R-squared ^c	0.95	.	0.62	.

^a Two-way clustered standard errors in parentheses, cluster variables: (route, quarter).

^b Huber-White robust standard errors in parentheses.

^c Within R-Squared.

*** p<0.01, ** p<0.05, * p<0.1

51. Excluding iron ore prices from the equation reduces the estimated elasticity of freight rates to Brent oil prices to 0.888 (see column 4). Excluding the BDI raises the elasticity about 10 times. In contrast to model 4, oil prices volatility is now estimated to be negatively correlated with freight rates and the relevant coefficient to be statistically significant (but small equal to -0.1, column 4). The coefficient associated with trade volumes (*trade*) remains positive, although much smaller (equal to 0.082 as compared with 0.424).

52. To sum up, iron ore freight rates are quite responsive to oil prices. After correcting for endogeneity and depending on the specification, a 10 per cent increase in Brent crude oil prices could result in increases in iron ore freight rates of up to 10.5 per cent. The estimated elasticity on trade is positive (although quite small when excluding the BDI and the price of iron ore). Finally, iron ore prices are found to be negatively correlated with iron ore freight rates.

III. Crude oil freight rates

53. In 2008, tanker trade accounted for over one third of world seaborne trade by volume. World shipments of tanker cargoes reached 2.75 billion tons, two thirds of which were crude oil. During the same year, Western Asia remained the main loading area of crude oil. Other exporting areas included South America, Central Africa and Northern Africa. Major importing regions included Europe, North America and Japan.⁷⁹

III.1. Data and model⁸⁰

54. This section investigates the effect of oil prices on the spot tanker freight rates. Spot tanker freight rates for the period 1996–2008 on eight trade routes (Arabian Gulf–Japan, Arabian Gulf–Republic of Korea, Arabian Gulf–North-west Europe, West Africa–United States Gulf of Mexico, West Africa–Caribbean/United States East Coast, Mediterranean–Mediterranean, North-west Europe–North-west Europe, Caribbean–United States East Coast) and involving various ship sizes (VLCC, Aframax and Suezmax) have been considered.⁸¹ Annual data on trade flows are available up to 2007.

55. To assess the effect of oil prices on tanker spot freight rates, the following models have constructed and estimated:

$$(6) \quad fre_{imy} = \lambda_i + \delta T_{my} + \beta_1 bre_{my} + \beta_2 vol_{my} + \beta_3 trade_{iy} + \varepsilon_{iqy}$$

$$(7) \quad fre_{imy} = \lambda_i + \delta T_{my} + \beta_1 bre_{my} + \beta_2 trade_{iy} + \varepsilon_{iqy}$$

where:

- fre_{imy} = representative spot freight rate (expressed \$/mt) on route i in month m of year y ;
- bre_{my} = price per barrel of Brent crude oil in month m of year y ;
- vol_{qy} = standard deviation of the price per barrel of Brent crude oil in month m of year y ;
- $trade_{iy}$ = trade flow on route i in year y , expressed in thousand barrels per day;⁸²
- λ_i = route fixed effect;
- T_{my} = time trend; and
- ε_{iqy} = stochastic error term.

⁷⁹ See UNCTAD (2009(b)): chapter 1.

⁸⁰ Once again, it should be noted that data reflecting the sharp fall in both oil prices and freight rates during the third quarter of 2008 could not be used in the regression analysis, as relevant trade data covering that period was not yet available for the purposes of this study.

⁸¹ Data on freight rates are sourced from Drewry's Shipping Insight. We wish to thank Parul Bhambri of Drewry for kindly providing access to the data and for clarifying the components of the spot tanker rates. Spot rates as published by Drewry take into account distance, fuel costs, sea margin (i.e. assumed delays at sea during transit), port costs, WS100 (i.e. Worldscale flat rate published by Worldscale Association annually for a variety of routes), the spot rate (i.e. Worldscale rate fixed by an owner for voyage chartering his ship on a particular route) and the commission paid to brokers.

⁸² Annual seaborne crude oil trade data are obtained from *Clarkson's Shipping Review and Outlook*, section 3, table 3.

56. Since in the present case, the oil price is also the price (value) of the commodity transported, we do not include the commodity price as an explanatory variable in the regression.⁸³ Moreover, the Baltic Tanker Index (BTI) Index is not included as potential explanatory variable for the same reasons as before with the BDI, namely the Baltic Tanker Index is an index of freight rates.

III.2. Estimation results⁸⁴

57. The effect of the value of the shipped commodity (i.e. price of Brent crude oil) is also captured by the estimated coefficient for the variable (bre_{my}). The measure of Brent crude oil prices volatility (vol) has been dropped from equation (7). To correct for potential endogeneity, the GDP of the importing region has been used as an instrument for trade volumes.⁸⁵

Table 7. Estimation of equations (6) and (7)

	(1) OLS ^a	(2) IV-GMM ^b	(3) OLS ^a	(4) IV-GMM ^b
Bre	0.446*** (0.0548)	0.224 (0.148)	0.545*** (0.0447)	0.281* (0.166)
Vol	0.233** (0.0985)	0.210*** (0.0807)		
Trade	0.284*** (0.0966)	3.049* (1.716)	0.287*** (0.0995)	3.435* (1.867)
Observations	1004	1004	1004	1004
R-squared ^c	0.54	.	0.52	.

^a Two-way clustered standard errors in parentheses, cluster variables: (route, quarter).

^b Huber-White robust standard errors in parentheses.

^c Within R-Squared.

*** p<0.01, ** p<0.05, * p<0.1

58. The OLS and IV-GMM results for model 6 are presented in columns 1 and 2, respectively. Results in columns 3 and 4 relate to OLS and IV-GMM estimations of model 7.

59. Based on the IV-GMM estimation, the coefficient of oil prices (bre) is positively (0.281) correlated with tanker freight rates and statistically significant in the model that excludes the

⁸³ The two variables would measure the same concept and they would be highly collinear.

⁸⁴ The elasticity is the percentage increase in the dependent variable caused by a 1 per cent increase in the explanatory variable. For percentage increases of more than 1 per cent, there is an approximation error. In the example, a 10 per cent increase is considered. As a result, an extrapolation from estimated elasticities beyond 1 per cent is subject to an approximation error.

⁸⁵ The instrument is the GDP at constant (2000) United States dollars, as before – UNCTAD Globstat data. We use the sum of the regional aggregates “Northern Europe” and “Western Europe” for North-west Europe, and the regional aggregate “Southern Europe” for the Med-Med route. In first-stage regression, the estimated elasticity of the instrument to trade is equal to 1 (standard error 0.49).

measure of Brent oil prices volatility (7). This result is similar to estimations obtained for containerized trade, albeit at a lower confidence level (10 per cent).

60. When a measure of the volatility of Brent crude oil prices is included as a potential explanatory variable (model 6), the coefficient for oil prices (*bre*) remains positive but no longer statistically significant. The measure of Brent crude oil prices volatility is positive and statistically significant (0.210) suggesting that greater volatility in Brent crude oil prices, drives up tanker freight rates. Any effect of oil prices (which is the commodity price on this market) on freight rates is therefore given by their volatility. Finally, although only significant at the 10 per cent level, the estimated coefficient for trade volumes (*trade*) is positive and very large (3.049 and 3.435).

D. SUMMARY AND DISCUSSION

61. Motivated, in particular, by the soaring crude oil prices recorded in 2008 and the flurry of speculations that followed with respect to their potential implications for trade and globalization, the present study examined whether – and if so, to what extent – maritime freight rates in container, dry bulk and tanker trades are affected by variations in marine bunker prices, using Brent crude oil prices as a proxy. Despite the heavy reliance of shipping on fuel oil and the fact that bunker prices account for a significant share of ship operating costs, there appears, so far, to be little empirical analysis of this issue.

62. Looking at bi-directional container trade flows on the main East–West container routes (transpacific, transatlantic and Asia-Europe-Asia) and after controlling for directional imbalances, and other potential determinants for container freight rates such as trade volumes (million TEU) and charter rates, and after correcting for potential endogeneity problems, container freight rates are found to be increasing with oil prices. The estimated elasticity ranges between 0.19 and 0.36, that is to say, a 10 per cent increase in Brent crude oil prices would lead to container freight rates increasing by around 1.9 per cent to 3.6 per cent. While Brent crude oil prices have been used as a proxy for ship fuel costs, regressing container freight rates on marine diesel oil (bunker fuel) prices resulted in similar findings. The elasticities for marine diesel oil prices range between 0.17 and 0.34. The results have not been altered when considering container freight rates per nautical mile and when correcting for inflation. Bearing in mind differences in datasets, methodology and objectives these results are overall in line with elasticities estimated in some of the existing literature.⁸⁶ Finally, the volatility of oil prices appears to have limited impact on the container freight rates.

63. The estimated positive elasticity confirms that oil prices do matter for container trade. Not only do they have an immediate effect on bunker fuel costs, but oil prices also have an effect on maritime freight rates.⁸⁷ The results of the present study have shown that the rise in container freight rates is not equivalent to (less than) the rise in oil prices.

64. The impact of rising transport costs resulting from a rise in oil prices may vary according to the type and value of goods shipped. On an *ad valorem* basis, transport costs usually matter more for lower value goods. Any such differentiated impact may entail some important implications for trade flows and patterns, especially for many developing countries, whose trade involves a large share of lower value goods (e.g. textile manufacturing) and who already face higher average transport costs. Nevertheless, it remains questionable whether an increase in container freight rates resulting from rising oil prices will, as has been argued elsewhere,⁸⁸ reverse globalization and reshape the structure and patterns of world trade. A study by Drewry, using a modeling approach found that labour and production cost differentials, quality control

⁸⁶ Estimated elasticities fall within the range of elasticities estimated, for instance, in OECD (forthcoming) and Hummels (2007).

⁸⁷ See also Fuel Prices, Transport Costs, and the Geography of Trade (UNCTAD (2008(b)). See in particular, figures 1 and 2.

⁸⁸ See for example Rubin and Tal (2005).

requirements, differences in tariff regimes and supply chain responsiveness and agility appear to play a more important role in outsourcing decisions than do transport costs.⁸⁹

65. Results have also shown the presence of a structural break: the elasticity of oil prices on freight rates is slightly higher since 2004, when oil prices increased sharply and embarked on a steep upward trend. After controlling for endogeneity, the relevant estimated elasticities are around 0.40 (columns 2 and 4 of table 2). Put differently, the effect of oil prices on freight rates is slightly larger in periods of sharply rising and more volatile oil prices, compared to periods of low and stable oil prices. This is of particular interest in view of the fact that oil prices may be expected to reach sustained high levels over the coming decades due, in particular, to a supply and demand imbalance.

66. Bearing in mind and controlling for potential endogeneity problems, directional container trade imbalances are, as expected, found to have a large effect on container freight rates (estimated coefficients of 1.90 and 2.10, depending on whether the variable for charter rates *har* is included). A 10 per cent increase in the container cargo imbalance on a given container route would lead container freight rates to increase by about 19 per cent to 21 per cent. The estimated elasticities suggest that container trade imbalances are much more important for container freight levels than oil prices. A logical implication would be for efforts aimed at controlling container maritime transport costs to also focus on addressing the trade imbalances (e.g. promoting greater information and equipment sharing, freight pooling, and cooperation among transport service providers in order to reduce empty movements).⁹⁰

67. As expected, container trade volumes are found to be negatively correlated with freight rates (-0.22 and -0.32, depending on whether or not the variable for charter rates *har* is included). Assuming a 10 per cent increase in container trade volumes, container freight rates would fall by about 2.2 per cent to 3.2 per cent. This result is generally in line with the existing literature which finds that economies of scale in containerized shipping lower unit transport costs.⁹¹

68. The second part of the study focused on a select commodity, namely iron ore. During the last few years, the cost of shipping iron ore has increased substantially, in view, among others, of the sustained global demand driven by Asian economies, especially, China. A model of iron ore freight rates as a function of the price per ton of iron ore, trade volumes, Brent crude oil prices and their volatility, and the BDI (depending on the specification) was estimated. After correcting for potential endogeneity problems and irrespective of the specification of the model, the estimated elasticities of iron ore freight rates to oil prices are found to be positive and statistically significant (1 per cent level). In the model that excludes the BDI, the estimated elasticity is found to be large ranging between 0.89 and 1.05, depending on whether or not iron ore prices are

⁸⁹ Drewry (2007). Supporting this view is a recent study which concludes that there is no strong empirical evidence that higher oil prices will result in a de-globalization in favour of regionalism (Mirza and Zitouna (2009)). The dramatic increase in oil prices recorded over the recent years, is found to have little effect on the relative changes in countries' probability to export to the United States (extensive margins) as well as on their relative market shares (intensive margins).

⁹⁰ Wilmsmeier and Sanchez (2009).

⁹¹ See for instance, Marquez-Ramos *et al.* (2006), Wilmsmeier and Martínez-Zarzoso (2010) and relevant literature cited in Behar and Venables (2010).

included.⁹² This suggests that an increase in Brent crude oil prices could result in equivalent or even larger increases in iron ore freight rates. Assuming an oil price increase of 10 per cent, iron ore freight rates would increase by about 8.9 per cent to 10.5 per cent. These results are consistent with OECD (forthcoming), where oil prices are found to be highly correlated with maritime transport costs of bulk products (using the Baltic Capesize Index). A potential explanation put forward is that speculation is prevalent in respect of the Baltic Capesize Index components and oil and that both are driven by developments in capital markets.

69. Another reason for the large estimated elasticities of iron ore freight rates to oil prices might be that the demand for iron ore is relatively inelastic, at least in the short term. This is because the potential for substitution by other minerals is limited, given the importance of iron ore as a major input in the steel production. Also, finding alternative sourcing locations and suppliers can be difficult with, as noted above, a handful of exporters supplying global demand for iron ore. Iron ore freight rates may also be more sensitive to changes in oil prices due to the inability of some cost-cutting strategies, such as low steaming to act as a shock absorber (e.g. limits imposed by existing ship technology, fuel efficiency of older bulkers, etc.) or using other modes of transport. When comparing with the elasticities estimated for container freight rates, it is important to note that container freight rates, as shown above, may be much more sensitive to other factors such as trade imbalances (and economies of scale which are also reflective of ship sizes, technology, port handling efficiency and the quality of port infrastructure).

70. The analysis has also shown that iron ore prices are negatively correlated with iron ore freight rates, suggesting that the larger the price of iron ore, the lower the freight rates. This result is at odds with the findings of some existing literature. For example, in one study (Tsolakis, 2005) – based on data that precede the boom in bulk trade (latest data used refer to 2002) – a positive and statistically significant elasticity of freight rates to iron ore prices is estimated for both Panamax and Cape size bulk carriers. The different results may be data-related. Our data on iron ore prices go back only to 1999 and are expressed as yearly averages, while data on iron ore freight rates are on a monthly frequency. Moreover, our data cover, in particular, the period during which a historical boom in the dry bulk trade, driven mainly by China's dynamic import demand for raw materials, was observed. In this context, the benchmark pricing system specific to the iron ore trade may also be of relevance.⁹³ Increases in the annually negotiated benchmark iron ore prices, may lead major importers such as, in particular China to reduce their dependence on imported iron ore by increasing local production and sourcing. A consequent fall in demand for bulker services is likely to dampen freight rates. It is also possible that lower iron freight rates push iron ore producers to demand and apply a "freight premium" to the benchmark iron ore prices.

71. Results have also revealed that iron freight rates increase with increases in iron ore trade volumes.⁹⁴ This finding is expected, given the particularly buoyant bulk trade driven by industrialization and growing demand for raw materials of emerging dynamic developing countries, especially China. As growing volumes reflect an increased demand, the positive correlation results from the demand and supply interaction and indicates the presence of a

⁹² As noted earlier (see para. 42, above), including iron ore prices as a potential explanatory variable entails some shortcomings.

⁹³ For additional information see, for example, UNCTAD (2009(a)).

⁹⁴ For similar results, see for example, Tsolakis (2005).

scaling-up effect (more demand shifts the equilibrium up the supply curve). Increased demand combined with limited bulker supply capacity, at least in the short term, may push iron ore freight rates upward. Larger trade volumes may also entail some costs associated, in particular, with additional operating and handling requirements that result from the need to handle larger volumes with constrained infrastructure, inefficient equipment and old and less fuel-efficient bulkers. Finally, increased trade volumes may drive up congestion, which in turn raises costs.⁹⁵

72. The last part of the study focuses on freight rates for seaborne crude oil trade. A model has been estimated where crude oil freight rates depend on Brent crude oil prices, their volatility as well as on trade volumes (instrumented using the importing region's GDP). After controlling for endogeneity, the coefficient of Brent crude oil prices is estimated at 0.28 but is only statistically significant when the measure of the volatility of crude oil prices is excluded from the set of explanatory variables. Based on the estimated elasticity, a 10 per cent increase in Brent crude oil prices would result in an increase of about 2.8 per cent in tanker freight rates.

73. The difference in the estimated oil price elasticities of iron ore and tanker freight rates is worth noting. These differences probably reflect the fact that today, tankers and bulkers serve different end use markets with different sensitivities to the overall economic situation and respective freight rates being differently affected by the same variables.⁹⁶ Factors such as differences in the type of ships used and their fuel efficiency, distances travelled and the potential for congestion and operational challenges at times of a boom in world seaborne trade could have a role to play.

74. As expected, the coefficient for trade volumes is positive and large (3.049 and 3.345, after correcting for endogeneity), suggesting that the higher the volume of trade the higher the tanker freight rates. These results are consistent with results reported in some existing literature.⁹⁷ As previously noted in the case of iron ore freight rates, the study period coincides with a major boom in seaborne trade driven mainly by strong demand from emerging developing countries for raw materials and energy. An increased demand, matched with an inelastic tanker supply capacity, at least in the short run, may also push tanker freight rates upward. Growing volumes could also entail costs in terms of handling requirements and congestion at ports. Finally, the results may also reflect the specifics of the industry whereby in periods of sustained high demand for oil (increased trade) higher freight rates are charged to extract part of the rents associated with the trading.

⁹⁵ See for example, Moreira, Volpe and Blyde (2008), who raise the issue of congestion and its impact on freight rates. One case study on exports of dairy products in Argentina shows that surges in import and export flows in the Port of Buenos Aires has raised the time to handle containers from two to five hours which has increased the freight costs.

⁹⁶ See, for instance, Tsolakis (2005).

⁹⁷ For similar results, see for instance, Hawdon (1978) and Tsolakis (2005).

E. CONCLUDING REMARKS AND SUGGESTIONS FOR FUTURE RESEARCH

75. Maritime transport, enabled by, inter alia, technological advances and competitive transport costs, is estimated to handle over 80 per cent world trade by volume and over 70 per cent by value.⁹⁸ Understanding the determinants of shipping costs and their implications for transport and trade is, therefore, of the essence for traders, transport operators as well as policymakers and regulators. For many developing countries, international transport costs are already high and can often surpass customs duties as a barrier to international trade. While much of the existing literature has focused on determinants of transport costs such as distance, economies of scale, technology, infrastructure and regulatory frameworks, little empirical research has been carried out on the effect of oil prices. The potential effect of oil prices on maritime freight rates is, however, of particular interest, given (a) the heavy reliance of the maritime transport sector on fuel oil for propulsion and (b) the fact that fossil fuel reserves are increasingly depleting and high levels of oil prices may therefore be expected in the longer run.

76. Against this background, the objective of the present study was to improve the understanding of the relationship between rising and volatile oil prices and maritime freight rates. Towards this objective, regression analysis was used to estimate the degree of sensitivity of maritime freight rates to changes in Brent Crude oil prices (used as proxy for bunker fuel costs), focusing, in particular, on container transport. The study also attempted to extend the analysis to cover some dry and wet bulk trades (i.e. iron ore and oil).

77. The results of the investigation confirm that oil prices do have an effect on maritime freight rates in the container trade as well as in the bulk trade with estimated elasticities varying, depending on the market segment and the specification. Moreover, the results for container trade suggest the presence of a structural break, whereby the effect of oil prices on container freight rates is larger in periods of sharply rising and more volatile oil prices, compared to periods of low and stable oil prices. This entails some potential implications for maritime transport and trade, if oil prices resume their spiraling trend observed in 2007 and 2008 and reach sustained high (and possibly, unprecedented) levels. Future high levels of oil prices and any consequent increase in freight rates may be of particular relevance for lower value goods and, more generally, for the trade of developing countries whose transport costs are already higher.

78. It might be argued that the economic downturn that unfolded in late 2008 has alleviated the problem by driving down both oil prices and transport costs. However, as the downturn reflects a bust in the global economic cycle and is likely to be temporary,⁹⁹ it should not detract attention from the long-term implications of rising oil prices on transport and trade, nor should it downplay the urgent need to scale up investment in alternative energy and energy efficiency. Indeed, all things considered, it is evident that further increases of oil prices are to be expected and probably to levels which have not yet been reached. This is not only because of supply and demand pressures, but also due to a range of uncertainties that are associated with the energy sector. Some of these include, for example, (a) concerns over the expected future levels of proven oil reserves; (b) production levels and the prospects of a peak; (c) the prohibitive cost of

⁹⁸ Calculations are based on the international seaborne trade data published in UNCTAD (2009(b)), and the global trade data as obtained from Global Insight in 2007.

⁹⁹ See, for example, the liner shipping industry response to the recent rise in bunker fuel costs as reported in Clarkson Shipping, *Container Monthly Intelligence Monthly*, Vol. 11, No.12, 18 December 2009.

extracting non-conventional fossil fuels such as tar sand; (d) significant investment requirements; (e) time lags between the discovery of an oil field and its actual functioning; (f) forecast growth in the world population; and (g) energy consumption and additional energy requirements associated with climate change adaptation. While the need for investment in energy-efficient technologies is increasingly being recognized in view of climate change considerations and global efforts to mitigate greenhouse gas emissions, the results of the present study underscore the need to aim for fuel efficiency in investment decisions as well as in operational practices.

79. This study constitutes a step towards an improved understanding of oil prices as a determinant of maritime freight rates. Results obtained are, however, not exhaustive or comprehensive and, as in many cases of regression analysis, there are various caveats that may influence the results, including data availability and the limitations posed by the lack of disaggregation in the available data.¹⁰⁰ In this context, efforts to collect accurate relevant data¹⁰¹ should be a priority and further extended to include developing countries. While some insight into the relationship between oil prices and maritime freight rates has been gained, much more work is needed to further improve on the models used and refine the interpretation of the results. A next logical step would be to deepen the analysis and investigate further the extent to which sharply rising and sustained high levels of oil prices may affect maritime freight rates and to determine with greater accuracy any potentially relevant thresholds. More generally, it would be useful to intensify efforts to investigate the impact of maritime transport costs on the composition of global trade, volume and patterns.

¹⁰⁰ The inclusion of fixed effects addresses the potential omitted variable problem. Data disaggregation is particularly relevant for gravity estimations of freight rates impacts on trade.

¹⁰¹ See also OECD (2008).

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