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World economic growth and seaborne trade volume: Quantifying the relationship

Nektarios A. Michail

Economic Analysis and Research Department, Central Bank of Cyprus, Cyprus Business School, Department of Management and Economics, Cyprus University of Technology, 80 Kennedy Avenue, 1076 Nicosia, Cyprus

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ABSTRACT

This article quantifies the relationship between the world macroeconomic environment and the demand for seaborne transport, using annual data on the quantity of crude oil, petroleum products and dry cargo transported. Using a Vector Error Correction Model (VECM) we capture their long-run relationship with world GDP and the price of oil, which serves as a proxy for freight rates. The results suggest that all three categories are affected by changes in the world economic environment, albeit to a different extent. Responses to a shock in the price of oil support the argument of the price inelasticity of demand. Dividing the world economy into high, middle and low income countries suggests that the first two always have a positive effect on demand, while low income countries have a negative effect. The quantification of these effects has a wide range of implications in the shipping industry ranging from freight rate forecasts and the associated implications for long-term chartering of vessels, to shipping valuations, risk management, and the mode of financing.

1. Introduction

Despite the theoretical postulate that demand for shipping transportation should have an important impact on the maritime industry, there has been no study to elaborate on the effect, other than a simple exercise in Stopford (2013). As is well known, the world economy is probably the most important determinant of demand for transportation; however, this effect is limited to goods requiring sea transport and thus generic exercises will prove of little value. To fill this gap in the literature, this paper provides an answer to the question of how the world economic environment can affect demand for seaborne commodity trade, using the three categories offered by the UNCTAD database: dry cargo, crude oil, and petroleum products.[1]

Overall, the results suggest that a shock in world GDP has a positive effect on all categories of vessel-transported goods, with the magnitude of this effect being category-specific. Processed petroleum products, related to clean tanker transport, register the strongest effect from an increase in world growth. On the other hand, the price of oil, which is used as a proxy for freight rates appears to have a small negative effect on the amount of goods transported, supporting the view of demand inelasticity with regards to price.

Finally, we divide world GDP into country groups, aiming to examine whether growth across various areas of the world has a different impact on the categories. The results suggest that High and Middle income countries account for the majority of the reaction observed above, while the former has a stronger effect on dry cargo and the latter on oil and petroleum products (clean and dirty tanker transport). Economic growth in Low income countries appears to have a negative effect on seaborne trade, as higher income is likely to be associated with more domestic consumption and less exports. The results are important for various types of decisions in the shipping industry such as on the calculation of future freight rates

E-mail address: nektariosmichail@centralbank.cy..

[1] The data may appear to be overly focused on oil, however, 70% of the transported quantity by the end of the sample refers to dry cargo. In addition, the distinction between these three categories also coincides with the three types of indices the Baltic Exchange produces: dirty tanker index – crude oil, clean tanker index – petroleum products, and dry index – dry cargo. See discussion in Section 2.

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and the associated implications for long-term chartering of vessels, shipping valuations, and the mode of financing an owner may choose.

As already suggested, the existing literature does not appear to have placed much attention on this aspect. While the performance of shipping companies has been vastly researched (inter alia, Panayides et al., 2011; Merika et al., 2015; Lambertides and Louca, 2008), there has been little research as to the demand side of the shipping sector.

Implicitly, earlier studies support the idea that macroeconomic factors which influence demand are significant in the maritime industry. In particular, the literature on the topic has shown that variables which are closely related with the world economic outlook, like the G-7 industrial production (Papapostolou et al., 2014), and the changes in oil prices (Drobetz et al., 2010), play an important role in the risk outlook of shipping companies and subsequently to their overall performance. Macroeconomic factors are also important determinants of freight rate volatility as Lim et al. (2019) note. This result is in line with previous findings suggesting that freight rate volatility is strongly affected by oil price shocks (Gavriilidis et al., 2018), while freight market volatility spillovers are also found to be affected by adverse changes macroeconomic conditions such as the global financial crisis (Tsouknidis, 2016).

Freight rate volatility can potentially have an important impact on shipping firms, especially considering that freight rates are the most important factor that can explain and predict shipping stock prices, as Syriopoulos and Roumpis (2009) and Papapostolou et al. (2014) show. Furthermore, Bai and Lam (2019) suggest, freight rates are also the most important determinant of second-hand vessel prices, while freight rates are also positively correlated with vessel capacity utilization (Adland et al., 2018).

Freight rates tend to share common trend dynamics (Población and Serna, 2018) and thus understanding the impact global growth can have on the demand for shipping is particularly important since the maritime industry is a derived demand system. In particular, when seaborne trade volume grows, freight rates rise and more ships tend to be ordered to cover the increasing transportation demand (Bai and Lam, 2019). Even though recent studies acknowledge that this derived demand system depends on world economic activity (Yin and Shi, 2018), an explicit evaluation of how demand-side factors directly affect shipping markets has never been conducted and this is where this paper fits the existing literature.

The remainder of this paper is organised as follows: the next section provides an overview of the methodology and data employed in the estimation, Section 3 provides the estimation results and provides a discussion of the implications these have on the shipping industry, and the final section concludes.

2. Methodology and data

In order to examine the underlying economic relationships among the variables, we employ a vector error correction model (VECM) as introduced by Johansen and Juselius (1990). In its most general way, the model is defined such that:

$$\Delta y_t = C + Ay_{t-1} + \sum_{i=1}^{n} B_i \Delta y_{t-i} + Dx_t + \varepsilon_t \quad (1)$$

where y_t is a vector of the (log) endogenous variables, C is the vector of estimated constants, matrix A contains the long-run coefficient estimates, matrix B contains the short-run coefficient estimates, and x_t includes deterministic exogenous variables, with D being the matrix of coefficient estimates for these exogenous variables. Δ is the first-difference operator.

As has been known in the literature (Engle and Granger, 1991), in the case where a variable has a unit root, the assumption of a constant error mean automatically does not hold. As such, any estimation in which variables have been found to follow a unit root process, e.g. such as the usual OLS framework, will lead the researcher to erroneous (spurious) conclusions (Phillips, 1986), where the *t*-test and the F-statistic do not converge as the sample increases.

The only alternative for proper conclusions is the case where the X and Y variables are interconnected, i.e. that they follow a similar long-run linear trend. This property was named co-integration by Engle and Granger (1987), and it specifies a series of tests which assert that the error term has a constant mean. However, the usual drawback with a simple regression estimation is that it does not allow for a feedback loop between the X and Y variables, given that the former are considered, by construction, independent. Not allowing for feedback loops can lead to significant inconsistencies in the estimations, especially in our case, where it is common knowledge that developments in one shipping sector (e.g. bulk) can easily spillover to another (e.g. tankers).[2]

A potential way to alleviate this would be to employ a Vector AutoRegression (VAR) methodology, introduced by Sims (1980), which allows for the existence of feedback loops between the variables, treating all variables as endogenous to the system of equations. Still, the presence of co-integration would also not allow for proper conclusions, given that the errors would also have been affected in this case. Thus, the VECM provides a breakthrough in the modelling arsenal of the researcher, since it has the important benefit of combining the ability to account for co-integration, using a linear combination of the variables, while at the same time allowing for the variables to be treated as endogenous, thus maintaining the feedback loop between them. Thus, the VECM framework provides, in this case, the only suitable estimation methodology for the proposed setup.[3]

In Eq. (1), y_t contains world GDP (GDP) which accounts for the state of the world's macroeconomic environment, the price of oil (OIL) as a proxy for freight rates, and the quantities of three seaborne trade categories, in tonnes: crude oil loaded (CRUDE), petroleum products and gas loaded (PRODUCTS), and dry cargo loaded (CARGO). Data for seaborne trade were obtained from UNCTAD, and the price of oil and world GDP were obtained from the World Bank. All variables are expressed in natural logarithms. The sample ranges from 1975 to 2015.

At this point, a more detailed discussion regarding the data employed is warranted. The UNCTAD database provides an overview of the main categories of seaborne trade, namely liquids and dry. Given the important distinction between the end users of the liquids category the UNCTAD database offers an additional breakdown. In particular, the crude oil category refers to products which are mainly used for refining purposes and energy production, whilst petroleum products (e.g. naphtha, gasoline, kerosene, LNG) refers to products in which retail consumers are the most common end-user. As usual, dry cargo refers to the transport of goods either by bulk carriers (e.g. grain, iron ore, coal, bauxite), or by containerships.

Unfortunately, no further breakdown is available from the UNCTAD database, even though this could have been more useful for practical purposes. Breaking down dry cargo to bulk carriers and containerships would have been of much more use for the industry as it would allow to examine more specific effects. Unfortunately, such a distinction is not available. Still, it should also be noted that this is the most usual breakdown employed also by the Baltic Exchange. In particular, the Baltic Exchange produces three indices, i.e. the dirty tanker index, which relates to the UNCTAD crude oil category, the clean tanker index, which relates to the UNCTAD petroleum products category, and the dry index, which refers to the dry cargo category.

It should be noted that data are only available with a time lag, something which results in both advantages and disadvantages. On the negative side, the lack of recent data makes it difficult to examine whether the estimations would still apply in the case of a structural change in the industry, even though these events do not occur frequently. However, on the plus side, the fact that UNCTAD data are only available with a lag provides a good justification as to their accuracy, given that gathering the data from

[2] For shipping-related studies of this effect, see Veenstra and Franses (1997) and Poulakidas and Joutz (2009).

[3] As in all econometric methodologies, the VECM is also heavily dependent on data availability. While our data cover 41 years, which is in general considered a substantial amount of time, we are certain that a longer time-series of more than 41 observations would provide more accurate results. Furthermore, the use of a VECM does not allow for the construction of confidence intervals for impulse responses.

individual countries and other providers, as well as examining for their accuracy, is a time-consuming task.[4]

To put the data in perspective, we find it interesting to highlight the changes which have occurred in trade patterns over time: in particular, while crude oil used to account for approximately 45% of total seaborne trade in the beginning of the sample, this has declined to approximately 18% in 2015. This, however, should not be viewed as a decline in the quantity of crude oil demanded, given that the overall amount of metric tons transported has increased by more than 30% over time, but as an increase in the dry cargo category, which has seen an almost 7-fold increase in the transported quantity. As such, dry cargo accounts for approximately 70% of total transport quantity in 2015. Similarly, petroleum products have increased by more than 4 times in the timeframe of our sample, but only account for roughly 12% of total seaborne trade.

Returning to the methodology employed, the rationale behind the choice of the two variables (oil price and world GDP) is straightforward as these serve to capture the factors which are mostly relevant to identify changes in the demand side of seaborne transport.[5] In particular, the price of oil serves as a proxy for the cost of freight given that it universally affects the cost of transport irrespective of the type of vessel. This is especially useful given that a long series of freight rates is not readily available.[6]

Overall, we expect that the price of oil should have a negative impact on the demand for seaborne transport. World GDP is a proxy for the overall increase in demand, as higher rates of growth will usually be associated with higher consumption which usually necessitates more international trade and hence demand for transport would increase (Stopford, 2013).

To examine whether the variables are suitable for inclusion in a VECM, we first test for stationarity. The results, available in Table 1, are supportive of the view that almost all variables exhibit I(1) behaviour, using the GLS-DF test proposed by Elliott et al. (1996). The exception, PRODUCTS, does not follow a unit root process but only because breaks exist in the series. This is confirmed by the breakpoint unit root tests developed by Perron (1989), Perron and Vogelsang (1992a, 1992b) and Vogelsang and Perron (1998). Hence, we proceed to estimate the VECM using one lag based on the Hannan-Quinn and Schwarz information criteria.[7]

The order specifies CARGO first, followed by PRODUCTS, CRUDE, GDP and OIL. The model is robust to changes in variable order, and this is further confirmed by the generalised impulse responses (GIRF) of Pesaran and Shin (1998). The GIRF results are available upon request. All estimation residuals abide the normality hypothesis, further confirming the suitability of the co-integrating relationship. The presence of co-integration was confirmed via the Johansen (1991) Trace and Maximum Eigenvalue tests. Although not reported, but are available upon request, both tests indicate the presence of three co-integrating equations.

Similar to other studies employing co-integration analysis (e.g. Papapetrou, 2001; Sharma and Panagiotidis, 2005; Zachariadis and Pashourtidou, 2007) we do not report confidence bands for impulse responses, given that these are not available in a standard co-integration setup. The following section presents the direct effects stemming from these co-integrating equations as well as the total effects which are captured by impulse response analysis.

[4] For more details on the data, see Review of Maritime Transport, 2018.

[5] With regards to the databases employed, the World Bank is perhaps the only provider of accurate World GDP data, and the breakdown of GDP in income groups, which are freely available from its database. Despite this "monopoly" of a data source for world GDP, the World Bank is in general highly regarded for its data quality. The price of Oil is also obtained from the World Bank.

[6] The only other proxy for freight rates which is freely available relates to the Global activity index of Kilian (2009), which however only associates to global macroeconomic conditions and not freight rates per se.

[7] Changes in the number of lags yield qualitatively similar results. These are available upon request.

Table 1
Unit roots and stationarity tests.

Variables	GLS Dickey-Fuller		Breakpoint unit root test	
	Levels	Difference	Levels	Difference
GDP	−0.20	−3.25[a]	−4.70	−4.80[a]
OIL	−1.22	−5.68[a]	−3.95	−8.24[a]
CRUDE	−1.22	−5.00[a]	−3.92	−5.68[a]
PRODUCTS	0.82	−1.26	3.55	−11.88[a]
CARGO	2.29	−5.56[a]	−2.36	−8.68[a]

[a] Rejects the null hypothesis at the 1% level.

3. Direct and total effects of demand factors

3.1. The world economy

Table 2 presents the estimated co-integrating equations. As the Table indicates, world GDP is positively correlated with the quantity of dry cargo and petroleum products transported. In particular, it appears that a 1% increase in world GDP would increase the quantity of dry cargo and petroleum products transferred by approximately 0.30%, while the quantity of crude oil transported is increased by 0.2%.

Oil prices do not appear to have a direct impact on the quantity of crude oil transported, perhaps due to the fact that oil contracts are usually of long duration. However, oil prices appear to have a negative impact on the quantity of petroleum products transported, as expected. This does not appear to hold for dry cargo, as it appears that higher oil prices result in higher demand for cargo.

This perhaps indicates that higher oil prices, and hence higher freight rates, are usually associated with higher demand for overall goods which, despite the higher price makes ship-owners more willing to transport it, as a result of higher potential for profit. However, it could be the case that this direct effect does not coincide with the total (i.e. both direct and indirect), systemic effects. To further examine the effects from increases in GDP and oil prices, we next present impulse responses from the system of equations, aiming to capture more than the direct effects from one variable to the other.

Fig. 1 provides the standard way of overviewing total effects in the VECM framework. In particular, the graphs, named impulse responses, illustrate the effect from an exogenous shock in the system of equations, which would cause one variable to increase by 1%. An exogenous shock is defined as one which originates in the error term, i.e. which stems from a cause which is not captured by the variables included in the estimation. In this case, a shock which increases economic growth can be viewed as one which stems from an improvement in productivity or an improvement in lending conditions, and in general, as one which is unrelated to seaborne trade. In a similar manner, a shock which increases oil prices can be viewed as unrelated to economic growth, and thus the demand side, and thus be related to the supply side, e.g. a tightening in oil production.

As such, impulse responses answer the question of how variables would respond in the case of an exogenous shock (i.e. not caused by the variables in the system) which causes one of the system variables to increase by 1%. In this case, Fig. 1 shows that an exogenous shock which increases world GDP by 1% makes the quantity of dry cargo transported increase by 0.2% in the short-run, with the impact dying out in the future. As such, we can interpret that world GDP has a positive impact on seaborne transportation quantity, to the extent of a 0.2% tonnage increase per 1% increase in economic growth.

Likewise, the response of petroleum products to a shock which increases world GDP by 1%, reaches 0.3% in the short run, increasing to approximately 0.71% in the long run. The quantity of crude oil transported, similar to the dry cargo case, appears to increase by approximately 0.23%. As Fig. 1 suggests, crude oil, petroleum products and dry cargo quantities do not move by much in response to a 1% increase in the price of oil. As the response is small, we can conclude that the view of an inelastic demand for transportation holds in these results. For the case of dry cargo, this is in

Table 2
Co integrating equation estimation.

Variables	Co integrating relationship (1)	Co integrating relationship (2)	Co integrating relationship (3)
Cargo(−1)	1.00	0.00	0.00
Products(−1)	0.00	1.00	0.00
Crude(−1)	0.00	0.00	1.00
GDP(−1)	−0.31*** (0.01)	−0.32*** (0.02)	−0.21*** (0.04)
Oil(−1)	−0.23*** (0.10)	0.28*** (0.06)	−0.30 (0.32)

Table 2 shows the co integrating equation results. The results should be interpreted using the opposite sign, i.e. a minus sign indicates a positive equilibrium relationship. The first three variables in each equation are forced to have the respective signs and magnitude, hence no standard errors are computed. ** and *** denote significance at the 5% and 1% level respectively.

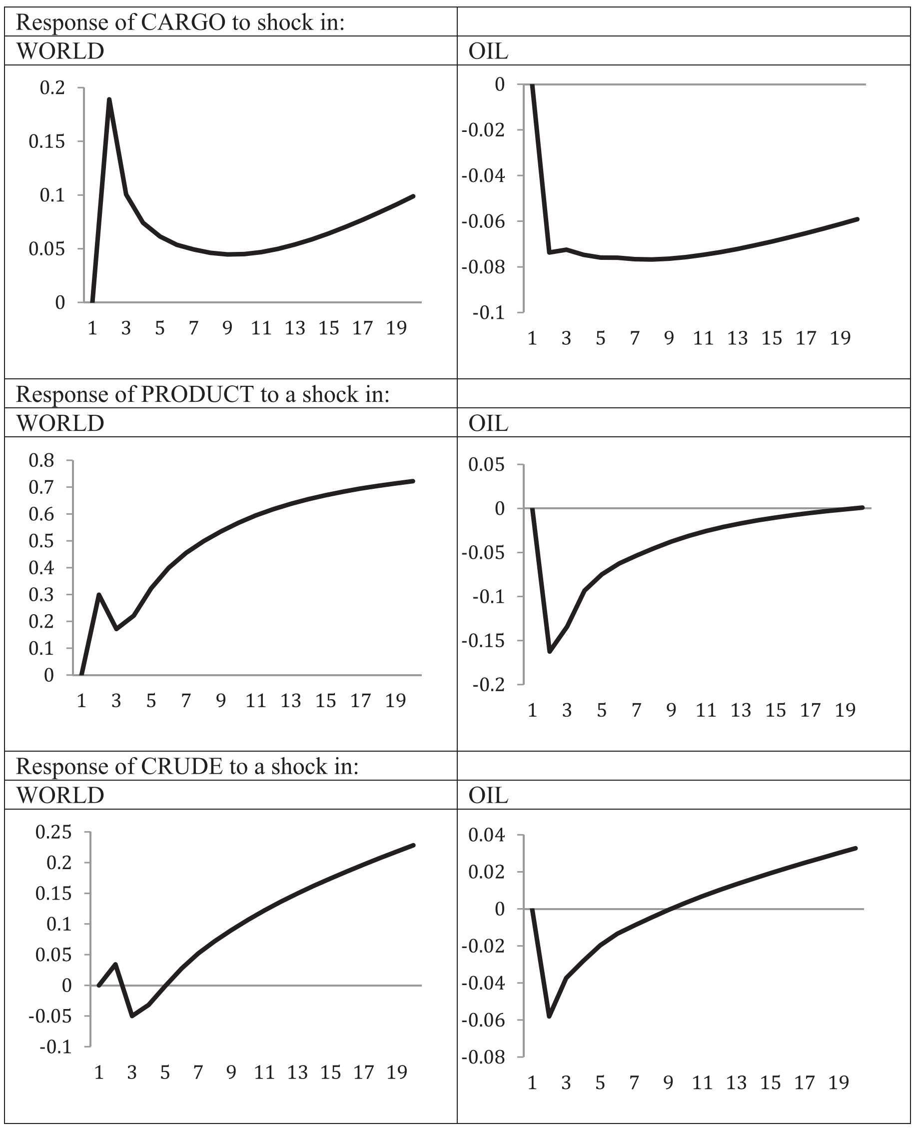

Fig. 1. The responses of shocks to the system.

contrast with the long-run results, most likely because only the direct effects were previously examined.

Overall, impulse response analysis confirms that economic growth has a strong effect on the quantity of seaborne trade. As Fig. 1 suggests, petroleum products register the strongest response to an increase in world economic growth, suggesting that demand for clean tanker transport could potentially face large ups and downs and thus cause significant volatility in freight rates, from the demand side. Naturally, it should be remembered that the overall effect on freight rates would also depend on the availability of vessels, as well as fleet capacity for sailing the specific distances required to reach the markets which register demand growth, two topics which could perhaps be explored by future research. Dry cargo demand is also positively affected by world economic growth, even though the extent is not as large, suggesting that demand is more stable across the business cycle, perhaps due to the nature of these products (e.g. coffee, grains), resulting in lower demand-side volatility. Overall, shipowners who operate vessels in petroleum products should expect larger movements stemming from the demand side, compared to their peers in the dry cargo and crude oil categories. Still, given that the geography of economic growth matters for transport categories, the following section proceeds with the division of countries to income groups.

3.2. Division to income groups

To further assess how the world economy affects seaborne trade we proceed by dividing world GDP into three country groups: High Income, Middle Income and Low Income countries, and examine how each country group affects the three categories of sea transport.[8] In particular, as the literature has demonstrated (Shahbaz et al., 2014) there are notable differences in the trade behaviour of countries which are in different income groups. For example, developed, high income, countries are expected to specialize in the production of those goods that are produced by human capital and manufactured capital-intensive activities. In contrast, developing economies, as per the Heckscher-Ohlin trade theory, should specialize in the production of those goods for which they have a factor endowment advantage such as labor and natural resources.

Furthermore, it is a well-known fact that middle income countries are heavy consumers of non-renewable energy sources, such as oil and coal (Paramati et al., 2017), as energy consumption is known to have been strongly correlated with growth (Wang et al., 2016). Thus, as middle-income countries (e.g. China, India, and Turkey) import larger quantities of oil and coal, the impact from a change in economic growth in such countries is expected to result in a higher elasticity of seaborne trade. Furthermore, the same countries are also known to be large exporters of goods, another category which is dependent on economic growth, hence they would also have a different effect on dry cargo sea transport volume than low income countries.

Developed (high-income) countries, on the other hand, which import a larger quantity of goods than any other group, are expected to have a strong impact on dry cargo. Still, the fact that these economies register much less growth volatility than middle-income ones, suggests that perhaps the impact may be smaller in this category. Furthermore, high income countries are usually exporters of high technology goods (Michail and Savvides, 2018), which suggests that economic growth, an important determinant of research and development activity (Choi and Yi, 2018), can also have a strong impact on seaborne transport.

In low income countries on the other hand, one would expect the opposite effect: as Low income countries (e.g. in Africa) are usually net exporters of oil and petroleum products, an improvement in economic growth would have a negative effect on seaborne trade, given that more Oil will be consumed domestically, and thus less will be exported. In a similar manner, low income countries are also exporters of agricultural products (e.g. coffee in Ethiopia) and other minerals (e.g. copper, and coltan in DRC), for which, when domestic demand increases, seaborne trade is reduced (Geological Survey, 2010).

As the above has elaborated, and as the subsequent analysis will demonstrate, there are significant differences between country groups, which more than justify the split. Understanding how seaborne trade will behave after changes in these country groups is of great importance: in the case where middle income countries contract, this could mean that some shipping operators, e.g. in petroleum products transport (clean tankers), would be affected by more than dry goods (bulk carriers). The remainder of the section will illustrate the extent of this effect.

Table 3 presents the estimated co-integrating equations. As the Table indicates, a 1% increase in the GDP growth rate of High Income countries will increase the transportation quantity of dry cargo by approximately 0.44% in the long run, if only direct effects are taken into consideration. Similarly, transportation of crude oil is expected to increase by approximately 0.40%. No statistically significant relationship is found between High Income countries and the quantity of petroleum products transported.

The possible reason behind this is probably because High income countries focus more on services and R&D, as we elaborated above, hence why dry cargo and crude oil are imported, and thus they are more affected by growth. High income countries are also large consumers of agricultural products (e.g. grain, starch) and minerals used for production (e.g. copper, silver), as well as finished goods, making them important players in this category. Further to this, the impact on the transportation quantity of crude oil can be justified since many refineries are located in high income countries.

On the other hand, if the GDP of Middle income countries increases by one percentage point, this would only increase the quantity of the petroleum products transported. No impact from Middle Income countries is found on the rest of the categories in Table 2, i.e. dry cargo and crude oil. This is probably because petroleum products are usually produced in Middle income countries, as most oil producers are generally included in this country group. Hence, an increase in their income could indicate that this was driven by an increase in exports. Lastly, Low income countries seem to negatively affect the transportation quantity of both the petroleum products and crude oil, albeit only to a small extent, probably for the reasons outlined above. No impact is registered for dry cargo quantities. This could perhaps be attributed to higher substitution for imported oil as more domestic energy sources are used as Low income countries grow.

Oil prices still have an important and similar impact to the previous specification. As before, a positive impact of approximately 0.80% in the dry cargo and 0.13% in the crude oil categories is registered. This suggests, as already mentioned in Table 2, that higher oil prices are often associated with higher demand for overall goods which result to higher potential profit, albeit this only captures the direct effect and does not allow for the shock to propagate through the system. On the opposite side, a negative correlation is registered when it comes to petroleum products. Again, we note that this does not constitute the full, systemic, effect but only the direct effect from the relationship.

Fig. 2 shows the impulse responses from the estimation. The transportation quantity of dry cargo increases by approximately 1% following a shock which increases High income countries' GDP by one percentage point. The increase is continuous and appears to stabilise at 1% only in the long run. A similar relationship seems to hold with Middle income countries where transportation quantity of dry cargo reaches approximately 0.7% in the long run. The dry cargo response to a shock in Low income countries is exactly the opposite, reaching −0.4% in the long run. Lastly, the response of dry cargo, to 1% increase of the oil price is negative, as expected, reaching −0.15% fast, and stabilising there.

Continuing with the responses, the transportation quantity of petroleum products increases by 0.35% following a shock which increases High income countries' GDP by 1%. A similar response appears to hold following a shock in Middle income countries. In particular, transportation quantity increases by more than 1% by year 6, after which it continues to increase, stabilising at a maximum of 1.25% in the long run. Similar to dry cargo, there is a negative relationship between petroleum products and Low income countries, reaching approximately −0.45% in the long run. Finally, this transportation category appears to, expectedly, decrease by 0.1% following an exogenous shock which increases oil prices by 1%.

The transportation quantity of crude oil appears to register a one-to-one long-run increase following a shock in High income countries. Crude oil transport also appears to increase in response to a positive shock in Middle income countries, albeit to a smaller extent, reaching a maximum of approximately 0.78% in the long-run. As with the previously-mentioned commodities, the relationship between Low income countries and crude oil appears to be negative and stable in the long-run, reaching a minimum of 0.45%. Finally, the category does not appear to respond much to an

[8] Data for the breakdown of countries, as well as the breakdown itself were obtained by the World Bank Database.

Table 3
Co-integrating equation estimation.

Variables	Co-integrating relationship (1)	Co-integrating relationship (2)	Co-integrating relationship (3)
Cargo(−1)	1.00	0.00	0.00
Products(−1)	0.00	1.00	0.00
Crude(−1)	0.00	0.00	1.00
High(−1)	−0.44*** (0.13)	0.03 (0.04)	−0.40*** (0.04)
Middle(−1)	0.08 (0.16)	−0.41*** (0.05)	0.02 (0.04)
Low(−1)	0.17 (0.12)	0.09** (0.03)	0.12*** (0.03)
Oil(−1)	−0.80*** (0.12)	0.19*** (0.04)	−0.13*** (0.03)

Table 3 shows the co-integrating equation results. The results should be interpreted using the opposite sign, i.e. a minus sign indicates a positive equilibrium relationship. ** and *** denote significance at the 5% and 1% level respectively.

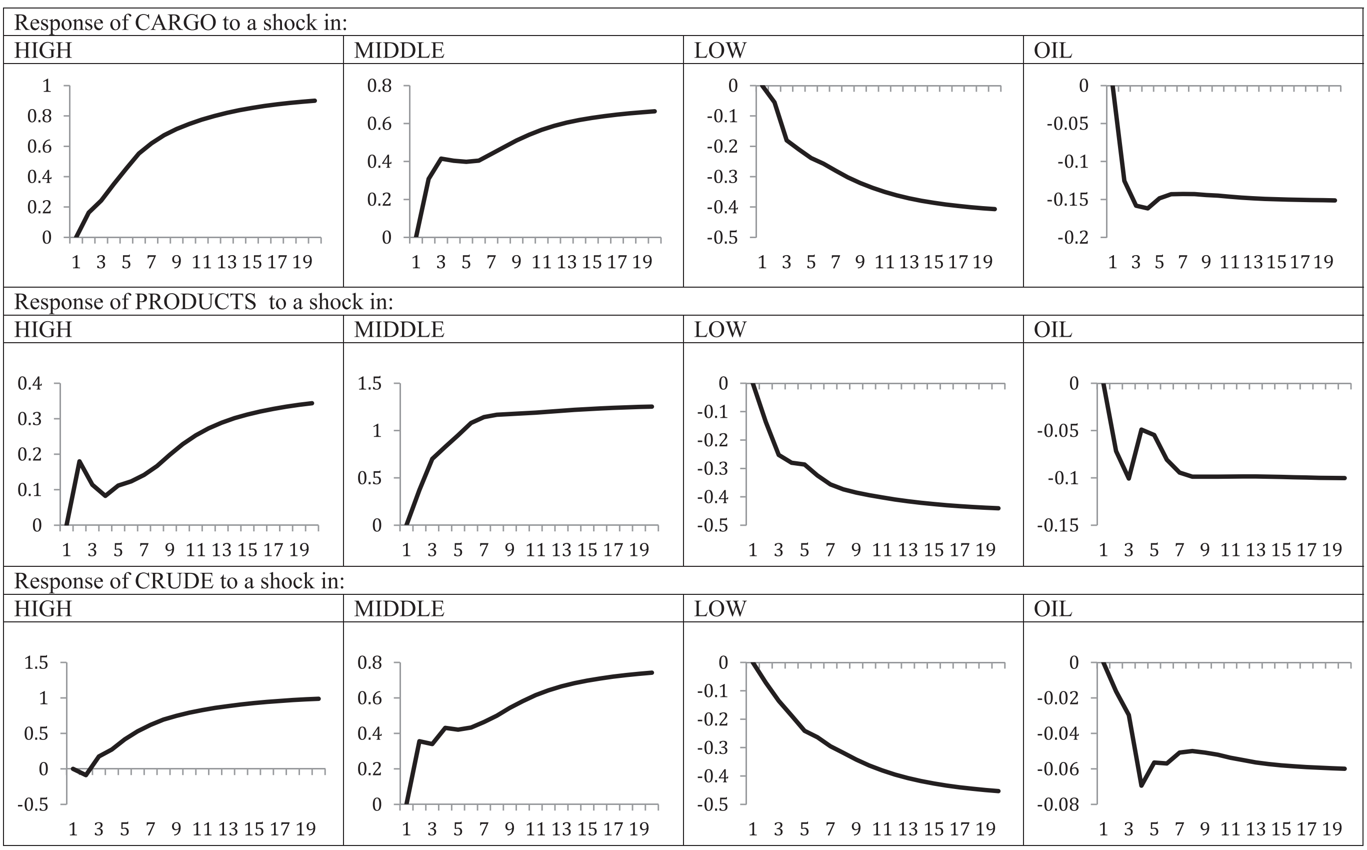

Fig. 2. The responses of shocks to the system.

increase in oil prices as the response is quantitatively small, reaching a maximum of 0.06%.

Overall, the results, which underline the importance of High and Middle income countries in the demand for transportation, are in line with Papapostolou et al. (2014), who show that the G-7 industrial production is a significant determinant of the performance of shipping companies. Given that industrial production is often used a proxy for GDP (e.g. Mitchell et al., 2005), our results provide support to this relationship.

Overall, the findings of this section suggest that an increase in High income countries' GDP would result in higher demand for dry cargo and crude oil, while Middle income countries have a stronger effect on petroleum products. As such, an increase in China's GDP should be expected to have a stronger impact on clean tanker transportation than on dry cargo, while resulting in higher demand for sea transport could also have an impact on freight rates, provided that no change in carrying capacity takes place.

3.3. Implications and discussion

Despite the simplified nature of the estimations, our results bear important implications for the industry: first, given that shipping supply is quasi-stable in the short-run, due to the time required for newbuildings to enter the market, being able to predict how demand for various types of cargo will evolve has an important bearing on the calculation of future freight rates and the associated implications for long-term chartering of vessels.

For example, if the economy appears to be registering high growth rates, with forecasts also suggesting growth in the future, a ship-owner may choose to operate his ship in the spot market, instead of securing a time-charter. In addition, following Fig. 2, an owner (or operator) would be more likely to react to projections regarding High income countries than Middle income ones, if he was operating a dry cargo vessel; in contrast, it would be more likely for a tanker owner (or operator) to react to forecasts regarding changes in Middle income countries' growth prospects.

Second, shipping valuations are inherently affected by changes in freight rates which are in turn also affected by demand for cargo transportation (Stopford, 2013). Hence, the ability to correctly anticipate how the world economy would evolve in the future can be a decisive factor with regards to purchasing, leasing or selling a vessel. For example, in the case where forecasts suggest that world growth would be lower in the years to come, then demand for seaborne trade can also be expected decrease. In this case, freight rates can also be expected to decrease, something which, ceteris paribus, would lead to lower future vessel valuations, given that freight rates are an integral part of the procedure to estimate the future cash flows from a vessel (Adland and Koekebakker, 2007; Tvedt, 1997; Thalassinos and Politis, 2014; Mayr, 2015).

On the basis of the above, a shipping valuator could employ our results to offer a more specific path with regards to where freight rates will evolve in the future; in this case, all else constant, lower growth would result in lower growth rates, lowering the vessel's potential for future income. As such, vessel valuations would be expected to decline in the case of a projected decrease in world growth. The results of the previous section could also be employed for more specific valuations: in the case a valuator would like to estimate the value of a tanker, projected growth in Middle income countries would matter more, given that they have a strong effect on those types of vessels, as Fig. 2 has shown. On the contrary, valuators of dry carriers would rely more on growth forecasts related to High income countries when it comes to providing their estimates.

Third, as Kavussanos and Visvikis (2016) suggest, market practitioners aim to, among others, minimize the impact of adverse price movements of freight rates, through the use of financial derivatives products, due to the volatile nature of the shipping industry. Understanding how future changes in demand can affect freight rates can be of great importance with regards to how this risk management process will evolve and the extent at which derivative products will be employed: if risks are mainly on the upside, given the projected evolution of the world economy, shipping companies may choose not to engage as much in financial derivative products; a projected increase in world growth would suggest that freight rates are likely to rise thus the need to employ financial products to safeguard from unforeseen movements is reduced. On the other hand, higher growth is likely to mean that oil prices would rise, which could mean that the firm would have to protect itself against such adverse movements which could hurt its profitability and thus use more financial protection.

The ability to forecast demand can also have an impact on the methods a ship-owner may select with regards to financing a new purchase as, understanding how demand will evolve affects the ability to charter or purchase a vessel. If world economic growth is forecast to persist, then a ship-owner could choose to front-load the majority of payments, in order to benefit from the improvement in market conditions and avoid getting into a more difficult situation if the economy faces a downturn. On the other hand, if world growth, or economic growth in the regions the ship is planned to operate is forecast to weaken, the ship operator can choose a form of financing which would delay large instalments, such as by issuing a bond.

Finally, stock trading strategies for listed shipping firms can also be formed on the basis of the relationship between GDP growth, demand for seaborne trade, and subsequently freight rates, whereby deviations from equilibrium could give rise to trading opportunities. A similar strategy, albeit not using macroeconomic information was presented by Michail and Melas (2019).

4. Conclusions

This paper has provided an estimate of the demand side of seaborne trade, by elaborating this can be affected by changes in the world economic environment and the price of oil as a proxy for freight rates. Overall, our results suggest that a shock in world GDP has a positive effect on all categories of transported goods, with the magnitude of this effect being category-specific. In addition, the price of oil appears to have a small negative effect on the amount of goods transported, supporting the view of demand inelasticity with regards to price. Finally, dividing world GDP into country groups, we find that high and middle income countries account for the majority of the reaction observed above, while Low income countries appear to have a negative effect. The results are important for various types of decisions in the shipping industry ranging from the calculation of future freight rates and the associated implications for long-term chartering of vessels to shipping valuations and the mode of financing an owner may choose.

The key takeaways from this paper focus on the fact that the quantity of goods transported via sea routes can be heavily influenced by world GDP growth. As such, even simplified demand-side models which can assist in capturing the future evolution of world GDP may be used by shipping firms, or other industry agents, in order to gauge the quantity of transported goods and the impact this could have on freight rates, a theme which could be potentially exploited by future research. Similarly, stock trading strategies can also be formed on the basis of this information allowing traders to profit from equilibrium deviations. To sum up, the most important lesson to be learned from the above is that the demand side of shipping should be explicitly taken into consideration, in particular with regards to the extent that this affects seaborne commodity trade due to the derived demand nature of the industry.

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