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Econometric estimation of second-hand shipping markets using panel data analysis

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Abstract

Panel data analysis is becoming increasingly popular in shipping markets since it enables the employment of a wider source of variation which allows a more efficient estimation of a model's parameters. This study applies an econometric analysis on a balanced panel data set of tankers' second-hand prices for five different vessel types as cross-section identifiers. Empirical analysis investigates the existence of second-hand prices' differentiation according to the vessel size using monthly observations for over a forty years time period. The key question concerns relationships among second-hand prices, spot rates and newbuilding prices and their dependence on whether vessel sizes experience low or higher rates of interdependence. Analysis focuses on the aspect of heterogeneity among variables, which is due to the effects of unobserved variables. The models estimate fixed and random effects and examine both cross section and time effects. Unit root and cointegration tests are performed in order to check for stationarity and for the existence of any long-run equilibrium relationships among variables. Also, Hausman test is adopted to test the existence of correlated random effects. Empirical results lead to conclusions and implications regarding the use of spot rates and newbuilding prices as intermediate means for the prediction of second-hand prices.

Keywords: Second-hand market, panel data analysis, cross-section analysis, fixed and random effects model
JEL Classification: C01, C33, C51

1. Introduction

Second-hand market is defined as the purchase and sale of vessels by shipowners. The purchasing and selling of second-hand vessels constitute a market with many particularities, where there is high risk and transactions are made under conditions of uncertainty and limited predictability about the future movement of second-hand prices. The risk of activation in this market is high and is highly related to the timing of investment.

In shipping industry, second-hand market is being addressed as one of the most dynamic and active. Participation in this market, contrary to the markets of newbuilding and scrap, doesn't increase or decrease any deadweight in the existing fleet. The only participants in this market are ship-owners, who are interested in purchasing and selling of vessels. A ship-owner sells a ship and another ship-owner buys it according to their plan of investments.

The simplicity of purchasing and selling vessels gives to this market the characteristics of competitiveness and at the same time the opportunity of easy entry or exit from the market. Prices of vessels are altered depending on the phase of the shipping circle in which shipping industry operates. As a result the ship-owners' investment decisions are influenced by their expectations about the phase of shipping circle in the future and especially if the freight market would move upwards or downwards. Consequently, the right choice of time to take the right investment decision constitutes one of the most critical factors of purchasing or selling a vessel.

Henceforth, vessels are treated by shipping companies as capital assets with independent cash-flows. Thus, companies structure a portfolio with decreased risk: the effective portfolio. This portfolio is the portfolio with the higher yield for a given level of risk or with the lower risk for a given level of yield, between the possible combinations of risk and yield, (Markowitz, 1952). This leads to the disequilibrium of second-hand market through asset play.

In terms of asset play, second-hand price constitutes the volatile component. Therefore understanding what determines second-hand prices is crucial to understanding the sources of fluctuations in demand. In addition, shipping's company decision to purchase and/or sell, which is the flow of capital investments, is important because it determines the size of asset play in a specific time period and thus affects the vessels' prices and finally the supply.

2. Literature review

All these very important aspects of second-hand ship market have led a number of researchers to study and develop theoretical and a-theoretical econometric models. During the previous decades a lot of researchers began to develop econometric models defining the adjustment path of second-hand prices. The first regular and detailed study was Beenstock's work (1985) that created a general model of equilibrium determining the prices of second-hand vessels. A theoretical model of prices determination was developed, disputing the classic shipping theory of analysis between supply and demand. Expected returns on ships are positively related with expected profits and prices. Capital flow into shipping raises ships' values reducing the return until the excess demand is eliminated. The opposite happens when return on other assets is increased. An increase in the fleet size implies that investors should hold a portfolio which is more heavily weighted towards ships in equilibrium. This loss of diversification increases risk, demanding price reduction. On the other hand, an increase in demand for assets is associated to an overall increase in wealth, which is spilling over into vessels and increasing their ticket price in kota bunga

This opinion was disputed by Tsolakis et al. (2003) showing that through an equilibrium model between supply and demand, it is possible for someone to interpret the market sufficiently. However, a criticism concerning that the variables which are used to determine demand and supply equilibrium, do not have essential statistical significance (t-statistic) weaken the estimated results.

Standenes (1984) investigated the sensitivity of ship prices on short-term and long term expected profitability and specified a relation between ship prices P_t, short-term profits π_t^S and long-term profits π_t^L, $Pt = k(u\pi_t^{s} + V\pi_t^{L})$, where k is a nuisance accounting constant, whose value is known a priori. Since, ships' economic lifetime is very long, short-term profits effect on prices is expected to be small whereas long-term profitability effect should be much longer. This indicates that the effect of long-term profitability on prices is much higher than the short-term profits effect. Only the prices of large tankers seem to be more sensitive on short-term profitability in relation to the level of long-term profits.

Hale and Vanags (1992) tried to prove the existence of long-lasting relations among the second-hand vessels' prices in the dry bulk market using stationarity and cointegration tests. Their results showed that the market is not effective, while they proposed the creation of an homogeneity indicator that will take into account all ships's types, in an aggregated analysis.

Glen (1997) extended the research of Hale and Vanags (1992) in the tanker market, proving the existence of long-lasting relations among second-hand vessels' prices. Nevertheless, Glen supported that the presence of cointegration relations, possibly does not reject the issue of market's effectiveness if the variables have a common stochastic trend.

Kavussanos (1997) examined the dynamic volatility of second-hand vessels' prices in the dry bulk market using ARCH and GARCH models proving that larger vessels have higher volatility. Kavussanos' work combined the new econometric techniques of time-series models with the existing financial theory and shipping economy.

Veenstra (1999) determined that the second-hand vessels' prices for all ships' types of dry bulk shipping are stationary at the first differences. This means that Veenstra examined the long-lasting relations through the cointegration issue. Variables that influence second-hand vessels' prices are timecharter prices, newbuilding prices and scrap prices.

Tvedt (2003) dealt with time-series models, presenting a different approach via the stationarity of variables. Contrary to the previous works and mainly this of Hale and Vanags (1992), he supported that the issue of random-walks can be rejected via the transformation of prices from the prevailing currency of dollar in that of yen. This concerns not only the freight prices but also the prices of second-hand vessels.

Kavussanos and Alizadeh (2002) proved the existence of a negative relation between the existing number of ships and price's volatility. They also claim that the existing fleet provides important information about the volatility and not for the future movement of prices. This lies to the fact that this information provides the characteristic of joint dynamic between vessel prices and the existing number of ships.

All previous studies have dealt with time-series econometric models. To our knowledge, there is not a previous effort to interpret second-hand market using panel data. This paper examines the dynamic relationship between second-hand prices and spot and newbuilding prices using panel data analysis.

The first research objective is to assess whether the second-hand market can be explained econometrically by the estimation of panel data analysis. It is an initial effort to analyze if there is a cross-section analysis of second-hand prices using as explanatory variables the spot and the newbuilding prices over several time periods. The second research objective is to examine if there are different estimating outcomes according to the vessel capacity. Therefore, coefficients from panel models concerning three different categories a) 5 cross-section units (5 vessels), b) 3 cross-section units (3 vessels-large capacity) and c) 2 cross-section units (2 vessels-small capacity) were compared.

Panel data allows the test for individual differences studying dynamic adjustment and measuring the effects of policy changes.

This paper supports that panel data estimation methods can be applied to explain econometrically second-hand prices of tanker market. Results indicate that there is a lead-lag relationship from both explanatory variables (spot and newbuilding prices) to second-hand prices, estimating panel random effect models.

3. Estimation background

3.1 Panel data model specification

This paper uses panel data analysis for a number of reasons. Using panel data we can account for individual differences among cross-section units estimating heterogeneity issues. First of all, panel data analysis is useful for controlling for individual heterogeneity, as it suggests that variables are heterogeneous. Panel analysis also gives more informative data, more variability, less collinearity among the variables, more degrees of freedom and more efficiency and it is suitable to study the duration of an economic phenomenon like second-hand prices formation. It is also possible to highlight the speed of adjustments of second-hand prices to economic policy decisions. Finally, panel data analysis is better to identify and measure effects (fixed or random) that are simply not detectable in pure time-series data (Hsiao, 2003).

Analysis of this paper is based on two different approaches of panel analysis. Firstly, it takes into consideration the hypothesis that separate categories of tanker market may have the same parameters. This pooling assumption imposes a common set of parameters across the second-hand prices during the estimation sample. Also, this assumption offers one very considerable advantage, which is related to the omitted variables. More specifically, the problem of omitted variables, which might cause biased estimates in a single linear regression model, may not occur in a panel context (Asteriou and Hall, 2007). Secondly, if the pooling assumption is not justified then a heterogeneous panel is estimated because the parameters are different across the vessels and the panel data estimator give some representative average estimate of the five categories of tankers' vessels.

3.2 The linear panel data model

The panel data model of this paper is based on a sample of 540 monthly observations that contains 5 cross-sectional units (vessels) that are observed at different time periods. The linear regression model is estimated under the regression assumption, which implies zero correlation among the examinant variables. There are several interesting and elaborate theories that seek to describe the determinants of the second-hand asset play process. Most of these theories evolve conclusions that spot and newbuilding prices are two important determinants of shipping's company investments in second-hand market. Except for the 5 cross-section units, panel analysis is expanded to the differentiation of vessels' capacity. More specifically, analysis split the vessels' capacity into two different sectors: the large vessels' capacity, which is comprised of three vessel types (VLCC, Suezmax and Aframax - 3 cross-section units) and the small vessels' capacity, which is comprised of two vessel types (Panamax and Handysize – 2 cross-section units).

The model has as dependent variable the second-hand prices and two explanatory variables, spot and newbuilding prices. In terms of spot and newbuilding prices, one important factor is to identify the present phase of shipping cycle. Spot prices represent and contain information about the expected profits of shipping market and newbuilding prices are affected by the size of orderbook and the existing fleet capacity. Consequently, spot and newbuilding prices may be used as explanatory variables for second-hand prices. It is also introduced some degree of heterogeneity (fixed or random effects) to estimate the behavioral differences in cross-section units of vessels.

3.3 Fixed Effects model

In the fixed effects method the constant is treated as group section-specific. The fixed effect model allows for different constants for each cross-section unit. The equation is given by the following form:

$$Yit= \alpha i + \beta_1 X_1 it + \beta_2 X_2 it + uit, \quad (1)$$

Where Y: second-hand prices, X_1: Spot prices, X_2=Newbuilding prices and αi= heterogeneity.

The first assumption in pooled regression is that the second-hand prices are linear in the variables and the parameters are fixed for all time periods and are the same for all vessel types. In this case, we can estimate a pooled regression and use the 2700 data points (540 observations x 5 cross-section units of vessels) to estimate parameters α, β_1 and β_2. Another assumption is that the parameters are different for each of the equations of vessels' types, but are fixed across time. In the fixed effects model, all vessel types' differences were captured by differences in the intercept parameter1. Also, we are making the assumption that errors (uit) are independent with mean zero and constant variance σ2e, for all individuals and in all time periods. Given this assumption, it follows that all behavioral differences between vessels' types and over time are captured by the intercept (Wooldridge, 2002).

The criterion, which is used to check if fixed effects should be included in the model, is the standard F-Test. (Baltagi, 2005).

3.4 Random Effects Model

This paper also tests a random effects model. The difference between the fixed effects and random effects method is that the latter handles the constants for each cross-section not as fixed, but as random parameters. The model takes the following form:

$$Yit= \alpha i + \beta_1 X_1 it + \beta_2 X_2 it + (\nu i + uit) \quad (2)$$

where νi is a zero mean standard random variable.

Another significant difference between the two possible ways of testing panel data models is that fixed effects model assumes that each vessel type differs in its intercept term, whereas the random effects model assumes that each vessel type differs in its error term. In the random effects model, all vessel types' differences are captured by the intercept parameters as previous, but also the vessels' types in our sample were randomly selected and for this reason the vessels' types were treating as random rather that fixed.

In the case of heteroskedasticity or autocorrelation, the estimation of random effects model follows the generalized least squares (GLS) estimator as is the minimum variance estimator.

To check for any correlation between the error component u_i and the regressors in a random effects model, a Hausman test is used. The test is crucial, because it compares the coefficient estimates from the random effects model to those from the fixed effects model.

3.5 Panel unit root tests

Unit root tests are also necessary to be implemented in panel data models. Although, there are some differences to implement unit root tests in comparison to time-series data, in the panel

[1] The fixed effect model of parameter variation specifies that only the intercept parameter varies, not the slope parameters. The intercept varies only across vessels' types and not over time (Hill et al. 2008).

data analysis we cannot ignore the validity of these tests. As Asteriou and Hall (2007) support, "*the additional cross-sectional components incorporated in panel data model provide better properties of panel unit-root tests compared with the low-power standard ADF for time series samples*".

The tests, which are used in this paper are the following: a) Levin, Lin and Chu, b) Im, Pesaran and Shin and c) Fisher type tests using ADF (Augmented Dickey Fuller) and PP (Philips-Perron) tests.

3.6 Panel Cointegration Tests

The motivation towards testing for cointegration is primarily linked with the provision of investigating the problem of spurious regressions, which exists only in the presence of non-stationarity. Test for cointegration, used in panels, is based on Engle-Granger cointegrating relationship known as Pedroni Test (Asteriou and Hall, 2007).

3.7 Granger Causality tests

Granger's causality test is useful to determine if change in one variable are a cause of changes in another. If one variable causes the other, then changes in first variable should precede changes in second. Also, the lagged values of first variable can be used to forecast the future prices of second variables (Pindyck and Rubinfeld, 1998). The existence of cointegration relations and the estimation of two-way causality among secondhand, spot and newbuilding markets points out the inefficiency of the shipping markets. Inefficient is the main reason of disequilibrium of markets which gives the opportunity for great profits or losses via asset play adopting different policies and strategies. Asset play is an important reason why inefficiency is the main characteristic of shipping markets, which present heterogeneity.

4. Data

Monthly panel data on five different vessels of tanker shipping market over the period 1970–2014 are exploited in panel data empirical analysis. The categories of tankers are: 1) VLCC (200,000 dwt +), 2) Suezmax (120,000–199,999 dwt), 3) Aframax (80,000–119,999 dwt) 4) Panamax (50,000–79,999 dwt) and 5) Handysize (18,000–35,000 dwt).

Data is obtained from Clarksons and especially from the Shipping Intelligent Network internet database. Eviews 6.0 software was used for the estimation of panel data models.

5. Estimation results

In this section, results of panel data estimations are presented. Panel unit root, cointegration and Granger causality tests are estimated for the examinant variables of second-hand, spot and newbuilding prices. They are also presented the estimation results of fixed and random effects models for all five cross-section units of vessels and also for the large and small capacity sectors with the correspondent dynamic multipliers. Empirical research concludes to a model, which covers statistical significance of the variables and also the heteroskedasticity and autocorrelation problems. The model is expressed as follows:

$$DLog(Second\text{-}hand) = \alpha i + \beta_1 * Log(Spot(-1)) + \beta_2 * DLog(Newbuilding(-2)) + \beta_3 * DLog(Second\text{-}hand(-1)) \quad (3)$$

5.1 Unit root tests results

Panel unit root tests (table 1), indicate unit roots in the level of second-hand and newbuilding prices. All tests (Levin, Lin & Chu, Im, Pesaran, Shin, ADF-Fisher, PP-Fisher) are concluded to the same results for all three categories of cross-section units as they are presented in table 1. On the contrary, spot prices seem to be stationary at their level as in time-series data (Geomelos and Xideas, 2014a). Logarithms' first difference of second-hand, spot and newbuilding prices are stationary. In this paper, a mathematical transformation has been used to avoid non-stationarity issues and consequently autocorrelation and heteroskedasticity problems, which would create spurious fixed or random effects regressions. First differencing is easier to be implemented when u_{it} follows a random walk and a heteroskedasticity-robust inference can be applied directly to cross-section units (Wooldridge, 2002).

Table 1

Panel Unit Root Tests

	(5 cross-section units – All vessels)							
Unit Root Tests	Levin, Lin & Chu		Im, Pesaran, Shin		ADF-Fisher		PP-Fisher	
Variables	**Statistic**	**Prob.**	**Statistic**	**Prob.**	**Statistic**	**Prob.**	**Statistic**	**Prob.**
Second-hand	-0,0032	0,4987	0,1596	0,5634	6,0252	0,8131	7,1051	0,7155
DLogSecond-hand	**-37,133**	**0,0000**	**-33,625**	**0,0000**	**633,46**	**0,0000**	**819,12**	**0,0000**
Spot	**-2,9915**	**0,0014**	**-7,6979**	**0,0000**	**88,238**	**0,0000**	**160,38**	**0,0000**
DLogSpot	**17,599**	**0,0000**	**-23,603**	**0,0000**	**423,72**	**0,0000**	**792,07**	**0,0000**
Newbuilding	-0,2019	0,4200	-0,101	0,4598	7,1181	0,7143	7,7929	0,6491
DLogNewbuilding	**-24,87**	**0,0000**	**-25,61**	**0,0000**	**486,55**	**0,0000**	**849,95**	**0,0000**
	(3 cross-section units – Large Capacity Vessels)							
Second-hand	-0,0913	0,4636	0,1480	0,5564	3,5205	0,7412	3,6640	0,7220
DLogSecond-hand	**-20,963**	**0,0000**	**-21,194**	**0,0000**	**317,406**	**0,0000**	**494,25**	**0,0000**
Spot	**-2,0451**	**0,0204**	**-6,0141**	**0,0000**	**54,321**	**0,0000**	**98,466**	**0,0000**
DLogSpot	**-0,5002**	**0,3084**	**-22,987**	**0,0000**	**330,311**	**0,0000**	**473,936**	**0,0000**
Newbuilding	-0,3738	0,3543	-0,4136	0,3396	5,2459	0,5127	5,19522	0,5190
DLogNewbuilding	**-14,103**	**0,0000**	**-18,543**	**0,0000**	**267,778**	**0,0000**	**516,435**	**0,0000**
	(2 cross-section units – Small Capacity Vessels)							
Second-hand	0,1163	0,5463	0,0787	0,5314	2,5046	0,6438	3,4411	0,4869
DLogSecond-hand	**-31,434**	**0,0000**	**-27,235**	**0,0000**	**316,056**	**0,0000**	**324,871**	**0,0000**
Spot	**-2,2188**	**0,0133**	**-4,8054**	**0,0000**	**33,917**	**0,0000**	**62,371**	**0,0000**
DLogSpot	**59,296**	**0,0000**	**-9,3001**	**0,0000**	**93,470**	**0,0000**	**318,138**	**0,0000**
Newbuilding	0,1167	0,5464	0,3488	0,6364	1,8722	0,7593	2,5977	0,6272
DLogNewbuilding	**-21,734**	**0,0000**	**-17,782**	**0,0000**	**218,777**	**0,0000**	**333,521**	**0,0000**
Numbers in bold indicate that variables are stationary								

Source: Authors

5.2 Panel Cointegration tests results

Panel cointegration tests theory implies that regression variables are a priori integrated of the same order I(1) to test for cointegration (Baltagi, 2005). This constitutes an additional reason why variables are transformed in the logarithm's first difference. Results for 5 and 3 cross-section units show that ten of the eleven statistics and for 2 cross-section units, nine of eleven statistics reject the null hypothesis of no cointegration (table 2). Cointegration tests show that there is at least one cointegrating vector among the variables. This cointegration relation is the proof of the existence of common stochastic trend among second-hand, spot and newbuilding prices. This is in accordance with the results of the cointegration tests in time-series data (Geomelos and Xideas, 2014a).

Table 2

Panel Cointegration Tests

(5 cross-section units – All vessels)				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob
Panel v-Statistic	**4.936635**	**0.0000**	0.939616	0.1737
Panel rho-Statistic	**-145.8736**	**0.0000**	**-129.3646**	**0.0000**
Panel PP-Statistic	**-40.29331**	**0.0000**	**-38.19932**	**0.0000**
Panel ADF-Statistic	**-34.95722**	**0.0000**	**-37.15889**	**0.0000**
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	**-147.1090**	**0.0000**		
Group PP-Statistic	**-48.26846**	**0.0000**		
Group ADF-Statistic	**-42.79792**	**0.0000**		
(3 cross-section units – Large Capacity Vessels)				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob
Panel v-Statistic	**5.474540**	**0.0000**	0.646812	0.2589
Panel rho-Statistic	**-120.0840**	**0.0000**	**-97.96010**	**0.0000**
Panel PP-Statistic	**-31.58915**	**0.0000**	**-28.50149**	**0.0000**
Panel ADF-Statistic	**-24.51997**	**0.0000**	**-27.15677**	**0.0000**
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	**-119.6090**	**0.0000**		
Group PP-Statistic	**-37.68127**	**0.0000**		
Group ADF-Statistic	**-30.88087**	**0.0000**		
(2 cross-section units – Small Capacity Vessels)				
Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob
Panel v-Statistic	1.082808	0.1394	0.701470	0.2415
Panel rho-Statistic	**-83.49766**	**0.0000**	**-84.78857**	**0.0000**
Panel PP-Statistic	**-25.11203**	**0.0000**	**-25.64826**	**0.0000**
Panel ADF-Statistic	**-24.99667**	**0.0000**	**-25.58111**	**0.0000**
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	**-86.10922**	**0.0000**		
Group PP-Statistic	**-30.16921**	**0.0000**		
Group ADF-Statistic	**-29.84827**	**0.0000**		
Numbers in bold indicate the existence of cointegration				

Source: Authors

5.3 Granger Causality results

Granger causality requires that series have to be covariance stationary, so we present the results of causality in series' first-differences. Also, we present the causality in the levels of the variables to see the differences in results. Since the Granger-causality test is very sensitive to the number of lags included in the regression, both the Akaike (AIC) and Schwarz Information Criteria have been used in order to find an appropriate number of lags.

The results from causality tests (table 3) show that a two-way relationship is established between second-hand and the spot and newbuilding prices for all cross section's categories. Thus, it can be argued that past values of spot and newbuilding prices contribute to the prediction of the present value of second-hand prices even with past values of second-hand prices with one time lag as it is expressed in equation (3).

To conclude, results of causality test provide evidence of a strong directional relationship, which can be found in the past values of spot and newbuilding prices and the current values of second-hand prices.

Table 3

Granger Causality Tests

F-critical value 12 lags (95%) = 1,76	5 cross-section units (All vessels)		units ty)		2 cross-se (Small	ction units apacity)
Null Hypothesis	Level	1st Difference	Level	1st Level	Difference	
SPOT does not Granger Cause **SECONDHAND**	**3.3761**	**5.2934**	**3.7960**	**3.3581**	1.5731	
SECONDHAND does not Granger Cause **SPOT**	**3.0209**	**3.6527**	**2.6233**	**2.1087**	**2.1760**	
NEWBUILDING does not Granger Cause **SECONDHAND**	**3.5747**	**4.7551**	**1.9318**	**1.8702**	**4.6851**	
SECONDHAND does not Granger Cause **NEWBUILDING**	**26.264**	**4.8400**	**18.554**	**2.8756**	**5.1082**	

Numbers in bold indicate that there is causality between the variables
Lag length is determined by AIC and SIC criteria

5.4 Fixed Effects model results

In the category of fixed effects panel models, three variables affect the dependent variable of second-hand prices (first-difference of logarithm) and more specifically spot prices with one time lag, newbuilding prices with two time lags and second-hand prices with one time lag for all three categories of cross-section of vessels (5,3 and 2 cross-section fixed effect model). These explanatory variables were found statistically significant (tables 4, 5 and 6), which affect the second-hand prices in long-term basis.

Tables 4,5 and 6 present that fixed effects are decreasing as the capacity of vessels is decreased. According to the fixed effects test via F-statistic, the hypothesis that the intercept parameters for all vessels are quite equal is accepted. This means that there are not differences in vessels intercepts and that the data should be pooled into a single model with a common intercept parameter. In other words, vessels capacity is different, but the difference in the vessels is correlated to the other X's variables and in particular with spot and newbuilding prices. So, the fixed effects would create omitted variable bias as they are correlated with the other independent variables. This result is the same either we examine the total number of vessels or both large and small categories of vessels.

In the model with 5 cross-section of vessels (table 4), the dynamic multiplier for spot prices is very low 0,0084 but confirms the positive relationship between spot and second-hand market. Also, the dynamic multiplier for newbuilding prices is 0,1172 and for second-hand prices with one time lag is 0,1320 with positive impact to the current level of second-hand prices. The intercept parameter is equal to -0,036 and it is the average value of fixed effects. It seems that the secondhand prices are affected mainly from the one time lag of second-hand prices and from the newbuilding market with a 2-month lag.

In the model with 3 cross-sections of vessels (table 5), the dynamic multiplier is also very low with a very little impact to second-hand prices, but multipliers of newbuilding prices with two time lags (0,193 instead of 0,117) and second-hand prices with one time lag (0,199 instead of 0,132) are higher in comparison to that of fixed model with 5 cross-section, which means that there is a higher positive impact. The average value of intercept parameters is equal to -0,0236.

Table 4

Fixed Effects Model (5 cross-section units)

Dependent Variable: DLOG (SECONDHAND)
Method: Panel EGLS (Cross-section SUR)
Sample (adjusted): 1970M04 2014M12
Cross-sections included: 5 Total panel (balanced) observations: 2685
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.036048	0.010663	-3.380559	0.0007
LOG(SPOT(-1))	0.008439	0.002338	3.609683	0.0003
DLOG(NEWBUILDING(-2))	0.117213	0.029998	3.907392	0.0001
DLOG(SECONDHAND(-1))	0.131959	0.019238	6.859398	0.0000

Fixed Effects Specification Cross section units

1 VLCC	-0.029650			
2 Suezmax	-0.033607	**Testing for Fixed Effects**		
3 Aframax	-0.036615	**F-stat.**	**1,94**	
4 Panamax	-0.039154	**F-crit.**	**2,38**	F(4,2677)
5 Handysize	-0.041216			95%

Weighted Statistics

R-squared	0.032252	Mean dependent var	0.037712
Adjusted R-squared	0.029722	S.D. dependent var	1.009534
S.E. of regression	0.994389	Sum squared resid	2647.044
F-statistic	12.74519	**Durbin-Watson stat**	**2.017352**

Table 5

Fixed Effects Model (3 cross-section units)

Dependent Variable: DLOG (SECONDHAND)
Method: Panel EGLS (Cross-section SUR)
Sample (adjusted): 1970M04 2014M12
Cross-sections included: 3 Total panel (balanced) observations: 1611
Linear estimation after one-step weighting matrix

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.023660	0.012036	-1.965764	0.0495
LOG(SPOT(-1))	0.006078	0.002832	2.145848	0.0320
DLOG(NEWBUILDING(-2))	0.193446	0.045001	4.298730	0.0000
DLOG(SECONDHAND(-1))	0.198702	0.024335	8.165171	0.0000

Fixed Effects Specification Cross section units

1 VLCC	-0.021001	**Testing for Fixed Effects**		
2 Suezmax	-0.023863	**F-stat.**	**1,15**	F(2, 1065)
3 Aframax	-0.026116	**F-crit.**	**3,00**	95%

Weighted Statistics

R-squared	0.059918	Mean dependent var	0.043507
Adjusted R-squared	0.056989	S.D. dependent var	1.030977
S.E. of regression	1.001161	Sum squared resid	1608.730
F-statistic	20.45950	Durbin-Watson stat	2.031513

The model, which examines the smallest deadweight of tankers, presents higher dynamic multipliers in relation to the categories of 5 and 3 cross- section vessels. The positive impact is higher for the smallest vessels and especially 0,292 for newbuilding prices with two time legs and 0,216 for second-hand prices with one time lag as table 6 shows. Also, the positive impact of spot prices with one time lag is very limited as in the previous fixed effects models.

Table 6

Fixed Effects Model (2 cross-section units)

Dependent Variable: DLOG (SECONDHAND)				
Method: Panel EGLS (Cross-section SUR)				
Sample (adjusted): 1970M04 2014M12		Periods included: 537		
Cross-sections included: 2		Total panel (balanced) observations: 1074		
Linear estimation after one-step weighting matrix				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
C	-0.028206	0.015487	-1.821196	0.0689
LOG(SPOT(-1))	0.005937	0.003092	1.920285	0.0551
DLOG(NEWBUILDING(-2))	0.291973	0.051715	5.645766	0.0000
DLOG(SECONDHAND(-1))	0.215826	0.029770	7.249890	0.0000
Fixed Effects Specification Cross section units				
1 Panamax	-0.027485	**Testing for Fixed Effects**		
2 Handysize	-0.028927	**F-stat.**	**0,23**	
		F-crit.	**3,84**	F(1,1069) 95%
Weighted Statistics				
R-squared	0.100803	Mean dependent var		0.002618
Adjusted R-squared	0.097439	S.D. dependent var		0.050520
S.E. of regression	0.047994	Sum squared resid		2.462360
F-statistic	29.95967	Durbin-Watson stat		2.042394

5.5 Random Effects model results

Random effects models permit the comparison of results of the same explanatory variables as in fixed effects models. In all three random panel models, estimations give a positive, statistically significant relationship among second-hand, spot(-1), newbuilding(-2) and second-hand(-1) prices. Also, the three models have been estimated through GLS method (Generalized Least Square) to avoid autocorrelation problem and to capture the Central Limit Theorem. This is depicted to the Durbin Watson statistic, which shows no serial correlation in the models (tables 7,8,9).

Hausman test shows that random effects estimator is consistent and it can be used for policy analysis. Second-hand prices are uncorrelated to the independent variables and the random effects estimator is fully efficient under the random effects model. Random effects are decreased as the vessel's capacity decreased as in the fixed effects model.

In the model with all 5 cross-section units (table 7) first lag of second-hand prices has an influential impact on current second-hand prices (0,208) as the second lag of newbuilding prices, which have the highest impact (0,255). The effect of spot price with one time lag is limited as in fixed effects models. This is due to the fact that spot prices follow during the sample under investigation a stationary track while secondhand prices present either increasing or decreasing trend. Values of random effects are ranging from -0,0202 to -0,0225, very close to the average intercept parameter (-0,0215) and they are much higher from the values of fixed effects.

Table 7

Random Effects Model (5 cross-section units)

Dependent Variable: DLOG (SECONDHAND)
Method: Panel Two-Stage EGLS (Cross-section random effects)
Sample (adjusted): 1970M04 2014M12 Periods included: 537
Cross-sections included: 5 Total panel (balanced) observations: 2685
Linear estimation after one-step weighting matrix
Wallace and Hussain estimator of component variances
Instrument list: C DLOG(Secondhand(-1)) LOG(Spot) DLOG(Newbuilding(-2))

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.021488	0.007408	-2.900722	0.0038
LOG(SPOT(-1))	0.005124	0.001618	3.166477	0.0016
DLOG(NEWBUILDING(-2))	0.255146	0.033703	7.570488	0.0000
DLOG(SECONDHAND(-1))	0.208444	0.018821	11.07480	0.0000
Random Effects Specification Cross section units				
1 VLCC	-0,02020			
2 Suezmax	-0,02098	**Hausman Test for Random Effects**		
3 Aframax	-0,02162	**Chi^2-stat.**		**6,81**
4 Panamax	-0,02212	**Chi^2-crit. (3) 95%**		**7,81**
5 Handysize	-0,02252			
Weighted Statistics				
R-squared	0.081015	Mean dependent var		0.002259
Adjusted R-squared	0.079987	S.D. dependent var		0.051356
S.E. of regression	0.049259	Sum squared resid		6.505421
F-statistic	80.54227	Durbin-Watson stat		2.050604
Prob(F-statistic)	0.000000	Second-Stage SSR		6.493674
Instrument rank	4.000000			

Estimates of interaction terms of independent variables are all positive (Table 8). The largest coefficient of 0,241 is that of newbuilding prices with 2 time lags. Additionally, second-hand prices with one time lag indicate a 0,221 coefficient. In other words, the return to second-hand prices is estimated to be 2,21% higher in a 10% change of the first lag of second-hand prices. Spot prices with one time lag have a very small effect in the current second-hand prices using panel data.

Random effects model with 2 cross-section (table 9) satisfies all the assumptions of Central Limit Theorem since there isn't any misspecification according to Hausman Test. Short-run multiplier of newbuilding prices with two time lags has a strong and significant positive effect on second-hand prices with a higher value (0,263 instead of 0,241 and 0,255) in relation the last two models. Random effects are the same for the vessels with the smallest capacity indicating that in long-term examination, it is difficult to identify significant differences between Panamax and Handysize vessels.

Table 8

Random Effects Model (3 cross-section units)

Dependent Variable: DLOG (SECONDHAND)
Method: Panel Two-Stage EGLS (Cross-section random effects)
Sample (adjusted): 1970M04 2014M12 Periods included: 537
Cross-sections included: 3 Total panel (balanced) observations: 1611
Linear estimation after one-step weighting matrix
Wallace and Hussain estimator of component variances
Instrument list: C DLOG(Secondhand(-1)) LOG(Spot) DLOG(Newbuilding(-2))

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.023715	0.009618	-2.465664	0.0138
LOG(SPOT(-1))	0.006056	0.002258	2.682463	0.0074
DLOG(NEWBUILDING(-2))	0.240517	0.043376	5.544902	0.0000
DLOG(SECONDHAND(-1))	0.221651	0.024238	9.144668	0.0000
Random Effects Specification Cross section units				
1 VLCC	-0,02295	**Hausman Test for Random Effects**		
2 Suezmax	-0,02366	**Chi^2-stat.**		**2,17**
3 Aframax	-0,02443	**Chi^2-crit. (3) 95%**		**7,81**
Weighted Statistics				
R-squared	0.085000	Mean dependent var		0.002439
Adjusted R-squared	0.083291	S.D. dependent var		0.052293
S.E. of regression	0.050068	Sum squared resid		4.028472
F-statistic	51.19273	Durbin-Watson stat		2.055464
Prob(F-statistic)	0.000000	Second-Stage SSR		4.018645
Instrument rank	4.000000			

Table 9

Random Effects Model (2 cross-section units)

Dependent Variable: DLOG (SECONDHAND)
Method: Panel Two-Stage EGLS (Cross-section random effects)
Sample (adjusted): 1970M04 2014M12 Periods included: 537
Cross-sections included: 2 Total panel (balanced) observations: 1074
Linear estimation after one-step weighting matrix
Wallace and Hussain estimator of component variances
Instrument list: C DLOG(Secondhand(-1)) LOG(Spot) DLOG(Newbuilding(-2))

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.045775	0.017813	-2.569743	0.0103
LOG(SPOT(-1))	0.009482	0.003559	2.664584	0.0078
DLOG(NEWBUILDING(-2))	0.262885	0.054291	4.842186	0.0000
DLOG(SECONDHAND(-1))	0.179916	0.030055	5.986251	0.0000
Random Effects Specification Cross section units				
1 Panamax	-0.045775	**Hausman Test for Random Effects**		
2 Handysize	-0.045775	**Chi^2-stat.**		**0,53**
		Chi^2-crit. (3) 95%		**7,81**
Weighted Statistics				
R-squared	0.077496	Mean dependent var		0.002523
Adjusted R-squared	0.074910	S.D. dependent var		0.049941
S.E. of regression	0.048034	Sum squared resid		2.468771
F-statistic	30.99074	Durbin-Watson stat		2.034684
Prob(F-statistic)	0.000000	Second-Stage SSR		2.462221
Instrument rank	4.000000			

6. Conclusions

This paper provides a first empirical econometric analysis in second-hand market using panel data models and especially fixed and random effects models. The primary aim of this paper is to highlight the key issues that should be considered when deciding whether to use fixed or random cross-section vessels effects in second-hand prices. To illustrate these issues, paper examines the determinants of second-hand prices using spot and newbuilding prices, as these variables are affecting mainly the second-hand market according to shipping economics. Models are based on the regression assumption, which specifies that there is a zero correlation among variables for both fixed and random effects models. Also, models cover the Central Limit Theory to avoid heteroskedasticity and autocorrelation problems.

Panel data models are taking into consideration, stationarity and cointegration issues. Both of these concepts are related to the correct specification of the models, where first-differences of the variables have been selected to overcome the presence of unit roots. Spot prices are stationary for the three separate cross-section units, but second-hand and newbuilding prices are non-stationary. The examinant variables of second-hand, spot and newbuilding prices are cointegrated leading to a direct dynamic causal two-way relationship. This two-way relationship is confirmed by Granger causality tests for all categories of cross-section vessels. More specifically, spot market interacts more with the second-hand market in large capacity vessels (VLCC, Suezmax, Aframax), while newbuilding prices interacts more in Panamax and Handysize vessels.

Research has been focused on the examination of both fixed and random models, because the production of relevant policies requires the estimation of both effects. Results confirm that causal inferences require randomized effects involving that the effects are uncorrelated with the independent variables and allow to model differential vessel effectiveness using random coefficients. In the context of second-hand prices, results highlight that the most appropriate panel data model is the random effects mechanism trough which spot and newbuilding prices with one and two time lags respectively (on the basis of individual characteristics) interpret significantly second-hand prices. Consequently, random models explain more accurately the differences across vessel’s sizes on second-hand prices. Therefore, capacity plays an important role in the determination of second-hand market.

Random effects are decreased as the vessel’s size increases and there is a distinguished difference in random estimator between 5 cross-section and 2 cross-section vessel units. This means that the examination of all five vessels simultaneously is not so accurate, compared to a disaggregation according to the vessel’s deadweight capacity. In contrast, examination of all vessels with the large capacity presents no significant difference in random estimator noting that larger vessels have the most influential impact in the second-hand market in a panel data analysis.

Analysis of findings gives rise to more-in depth research. Further research can be carried out by exploring more variables (either shipping and/or macroeconomic) to estimate and to compare the forecasting performance of panel data models in second-hand market.

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