

DEPARTMENT OF TRANSPORT AND REGIONAL ECONOMICS

**An analysis of entry and exit decisions in
shipping markets under uncertainty**

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RESEARCH PAPER 2015-013
MAY 2015

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D/2015/1169/013

An analysis of entry and exit decisions in shipping markets under uncertainty

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Abstract

Objective: The existing literature on the application of real options in maritime economics is rather limited. [Bendall & Stent \(2003, 2005, 2007\)](#) show how investing in a new ship or maritime technology can incorporate an option value. Another application is elaborated by [Bjerksund & Ekern \(1995\)](#), discussing the value of mean-reverting cash flows through contingent claim analysis, applied to time charters. The analysis of the entry and exit decision in the shipping markets can form an interesting extension of this research. Shipping markets are in nature uncertain and cyclical ([Stopford, 2009](#)). For this reason, the real options based model of [Ruiz-Aliseda & Wu \(2012\)](#) for stochastically cyclical markets will be applied to the shipping markets, in order to define entry and exit thresholds in this market.

Data/Methodology: Data on the freight rates, costs and ship prices are used for estimating the parameters present in the real options based model of [Ruiz-Aliseda & Wu \(2012\)](#) for stochastically cyclical markets. This model incorporates a discrete-time Markov process, an alternative for the traditionally used geometric Brownian motion (GBM) and suited to model the cyclical nature of the shipping markets. Investing in a ship and selling it again can respectively be interpreted as entering and exiting the market. Hence, the model can be applied here in order to predict the optimal values for entry and exit in the shipping markets.

Results/Findings: The theoretically calculated results will be tested on real cases using data on container time charter prices over different periods, to see how well the theoretically developed model performs in the shipping markets. In that way, the estimation of parameters and the assumptions of the model can be evaluated on their accuracy in these cyclical markets.

Implications for Research/Policy: In the first place, this case study can indicate how well the model performs in another market. If the model turns out to successfully predict market entry and exit thresholds, it could help companies to make better predictions on competitor behaviour. Also for policy makers, it could help to have a more accurate insight in the required capacity for ports.

Keywords: Cyclical markets, Real options, Shipping markets, Container, Entry and exit decisions

1 Introduction

Shipping markets are in nature cyclical, which means that growth and decline phases alter without knowing ex-ante the moment of transition from one phase to another (Stopford, 2009). Ex-post however, a firm can observe the phase they are in. This implies that it is impossible to predict turning points in these conjunctures. Nevertheless, knowing the appropriate moment to enter or leave a market is important for an entrepreneur to maximise his profits. In this regard, Ruiz-Aliseda & Wu (2012) developed a real options based model that can be used to estimate upper and lower price thresholds to enter or exit a competitive market. In this paper, this approach will be applied to the container business, where the decision of a shipowner to buy or sell a ship (market entry or market exit) will be analysed depending on the price they earn for the operation of that ship.

This paper is divided into 6 sections. Section 2 discusses the importance of entry and exit decisions with regard to the shipping market and some example applications of real options in a maritime context. Section 3 explains the methodology of Ruiz-Aliseda & Wu (2012). The data gathering and parameter estimations are reviewed in Section 4. In Section 5, the results are presented and discussed, also paying attention to policy implications. Section 6 contains the main conclusions and considerations for future research.

2 Market environment description

In a challenging market, it is important for an entrepreneur to take the right managerial and economic decisions. Amongst others it is crucial to know which is the right moment to enter or exit a market. Entering or leaving a market too early or too late could result in significant losses. Entering too late or leaving the market too early will result in missing an important part of possible future profit streams, whereas leaving too late or entering too early would imply incurring costs too high to be made up by the expected future profit stream.

In this paper, the entry and exit decision in the shipping market is studied. One of the first to research this subject was Mossin (1968), who points out the complex nature of the shipping market. In shipping, profits resulting from operational activities can be low. In addition, the crisis in 2008 had a strong impact on the maritime business. Demand for maritime transport fell drastically, whereas supply remained high, in turn resulting in overcapacity and low shipping rates (Heymann, 2008). In such a challenging market, it is even more important to take the right managerial and economic decisions (Stopford, 2009). Hence, actors involved in the maritime business are frequently contemplating about the right moment to enter or leave the market.

To study the entry and exit decision in the shipping market, it is important to define and analyse three elements of this market: the scope or studied submarket(s), the amount of competition in the market and the evolution of prices in the market. First in this paper, the scope is reduced to two shipping submarkets: the *sale and purchase market*, where ships are bought and sold in a second hand market; and the *freight market*, where shipowners earn revenue in exchange for transporting goods (Stopford, 2009). Moreover, this study focusses on the *container liner shipping industry* (CLSI). Nevertheless,

the proposed analysis can be applied and extended to other markets, e.g. bulk shipping.

One characteristic that is closely linked to entry and exit in a market is competition (Agarwal & Gort, 1996). To analyse the amount of competition, structural and non-structural approaches have been proposed and the hypothesis that the CLSI is characterised by perfect competition or a monopoly structure can be rejected (Sys, 2009; Sys et al., 2011), hence the market structure must be somewhere in between these two extremes. In addition, Sys (2009) noted that the amount of concentration in the industry is increasing. This is opposed to the structure of the bulk shipping industry, of which some authors believe that of all shipping submarkets it approaches perfect competition the best (Lun & Quaddus, 2009; Harlaftis & Theotokas, 2010).

The influence of the evolution of prices and shipping rates on the manager's entry and exit decision is substantial. Insight in this characteristic of the CLSI is important to be able to model it afterwards. According to Stopford (2009), shipping markets are in nature cyclical, implying periods of growth and decline following one after another. As a result, shipowners do take the *shipping risk* of incurring losses caused by the imbalance between supply and demand. When the market is in a peak, rates are relatively high compared to the costs, encouraging entry in the market. A trough however implies relatively low rates, which implies shipowners losing money (Stopford, 2009). This can be avoided by a well-timed exit in some cases, when the cost of leaving the market is below the expected losses incurred by staying in the market. An important consideration of firms in cyclical markets is that they can only observe ex-post the turning points in these cycles. This uncertainty complicates the decision to enter or leave a market at the optimal moment (Stopford, 2009; Ruiz-Aliseda & Wu, 2012).

In literature, Real Options Analysis (ROA) is suggested as an innovative alternative to better understand and make improved investment decisions in an environment characterised by uncertainty, (some) irreversibility and freedom in the timing decision (Dixit & Pindyck, 1994). Sødal (2006) used ROA in a discount factor approach to analyse entry and exit decisions in different kinds of market settings and under different assumptions. The outcomes of such an analysis are trigger or threshold values for an underlying variable, such as the market price, that indicate the appropriate moment for market entry or exit. A similar type of analysis could be applied to the switching decision between dry and wet bulk shipping involving combination carriers (Sødal et al., 2008).

To analyse entry and exit decisions under uncertainty in cyclical markets, Ruiz-Aliseda & Wu (2012) developed a ROA involving discount factors. This model does not encompass the geometrical Brownian motion (GBM), which is frequently used in ROA (Dixit & Pindyck, 1994), but a discrete-time Markov process to model the cyclical evolution of profits in the market. This model however assumes a competitive market. The analyses of Sys (2009) and Sys et al. (2011) indicated that the CLSI is not characterised by perfect competition. For this reason, this model is better suited to analyse the entry and exit decision for individual container shipowners. Such a market can reasonably be assumed to approach perfect competition. There are many buyers and sellers of ship services, everyone offers a similar product, time charter rates are merely influenced by individual shipowners and barriers to entry are limited (Martin, 2001). Indeed, shipowners can buy or sell a ship immediately on the second hand market, without significant time lags. It is exactly this decision that is considered in the

rest of this paper as entry and exit. Moreover, it is assumed that shipowners can charter their ship under a *time charter* agreement. In return for a given price per day, shipowners operate the ship for the charterer. This implies incurring operating and capital costs, while other costs like fuel, port charges and cargo-related costs are at the expense of the charterer (Stopford, 2009). Indices of such container time charter rates (e.g. Harpex Shipping Index, New ConTex, etc.) are available online and exhibit cyclical paths (Harper Petersen & Co, 2015; VHSS, 2015).

Another complication in shipping is that the different submarkets are linked to each other (Stopford, 2009). Hence, the sale and purchase market is linked to the freight market, also exhibiting cyclical price evolutions. In the model of Ruiz-Aliseda & Wu (2012) however, the cost of entrance and the redeployment value, here respectively being the buy and selling price of a container ship, are assumed to be fixed. This is not true because of the existence of the shipping cycles and the links between the different shipping submarkets (Stopford, 2009). In the short run however, these prices can be assumed fixed. As a consequence, analysing the sensitivity of the results to these prices could be valuable for the ship owners.

It is noteworthy that applications of real options in shipping are not limited to market entry and exit decisions. Bendall & Stent (2003, 2005, 2007) for example show how investing in a new ship or maritime technology can incorporate an option value. Another application of ROA in shipping is elaborated by Bjerksund & Ekern (1995), analysing the value of mean-reverting cash flows through contingent claim analysis, applied to time charters. Tibben-Lembke & Rogers (2006) proposed the introduction of financial call and put options in transportation.

3 Methodological background

In this paper, the model developed by Ruiz-Aliseda & Wu (2012) is used to analyse and optimise the decision process presented in Section 2. The authors model cyclical markets using a discrete-time Markov process for profits in stead of a geometric Brownian motion (GBM). Important parameters to model this Markov process are the probabilities of moving from one state to another (λ_1 is the probability of going from a growth to a decline phase and λ_2 is the probability of the reverse move) and the growth (α_1) and decline (α_2) rates. The parameter r is the discount rate used in the model, which is often chosen as 0.1 in real options models. All other variables, being the perpetuity factors in growth and decline phase ρ_1 and ρ_2 , β_1 and β_2 , δ_1 and δ_2 and Δ depend on these parameters. Also the auxiliary functions $\xi(\bar{\pi}, \underline{\pi})$ and $\zeta(\bar{\pi}, \underline{\pi})$ depend on these parameters and the unknown thresholds ($\bar{\pi}$ and $\underline{\pi}$).

The two unknown variables $\bar{\pi}$ and $\underline{\pi}$ will trigger entry and exit decisions. $\bar{\pi}$ indicates the threshold of the profit for a certain period, required to enter the market and $\underline{\pi}$ indicates the exit threshold, given the market's characteristics, the (investment) cost of entrance (K) and the recovery of cost in case of exit, also referred to as the redeployment value (S).

To calculate these thresholds, one has to numerically solve the following

system:

$$\begin{cases} \bar{\mathcal{E}}(\bar{\pi}|\bar{\pi}, \underline{\pi}) = K \\ \underline{\mathcal{E}}(\underline{\pi}|\bar{\pi}, \underline{\pi}) = S \end{cases} \quad (1)$$

In these expressions, $\bar{\mathcal{E}}(\bar{\pi}|\bar{\pi}, \underline{\pi})$ and $\underline{\mathcal{E}}(\underline{\pi}|\bar{\pi}, \underline{\pi})$ stand for the expected discounted profits in respectively a growth phase (currently at $\bar{\pi}$) and a decline phase (currently at $\underline{\pi}$), with $\bar{\pi}$ and $\underline{\pi}$ being the upper and lower limits of the profit. The rationale behind this system of equations is that in the upper bound of a growth phase, one at least wants to recover the cost of investment, and that in the lower bound of a decline phase, you only want to give up a profit stream that is at maximum equal to the redeployment value.

Using the definitions of [Ruiz-Aliseda & Wu \(2012, p. 809–810\)](#), we arrive through

$$\begin{cases} \xi(\bar{\pi}, \underline{\pi})\bar{\pi}^{\beta_1} + \delta_1 \zeta(\bar{\pi}, \underline{\pi})\bar{\pi}^{\beta_2} + \rho_1 \bar{\pi} = K \\ \delta_2 \xi(\bar{\pi}, \underline{\pi})\underline{\pi}^{\beta_1} + \zeta(\bar{\pi}, \underline{\pi})\underline{\pi}^{\beta_2} + \rho_2 \underline{\pi} = S \end{cases}$$

at

$$\begin{cases} \frac{\delta_1 \bar{\pi}^{\beta_2} \rho_2 \underline{\pi} - \rho_1 \bar{\pi} \underline{\pi}^{\beta_2}}{\beta_1 (\bar{\pi}^{\beta_2} \bar{\pi}^{\beta_1} - \delta_1 \delta_2 \bar{\pi}^{\beta_1} \bar{\pi}^{\beta_2})} \bar{\pi}^{\beta_1} + \delta_1 \frac{\delta_2 \bar{\pi}^{\beta_1} \rho_1 \bar{\pi} - \rho_2 \bar{\pi} \bar{\pi}^{\beta_1}}{\beta_2 (\bar{\pi}^{\beta_2} \bar{\pi}^{\beta_1} - \delta_1 \delta_2 \bar{\pi}^{\beta_1} \bar{\pi}^{\beta_2})} \bar{\pi}^{\beta_2} + \rho_1 \bar{\pi} = K \\ \delta_2 \frac{\delta_1 \bar{\pi}^{\beta_2} \rho_2 \underline{\pi} - \rho_1 \bar{\pi} \underline{\pi}^{\beta_2}}{\beta_1 (\bar{\pi}^{\beta_2} \bar{\pi}^{\beta_1} - \delta_1 \delta_2 \bar{\pi}^{\beta_1} \bar{\pi}^{\beta_2})} \underline{\pi}^{\beta_1} + \frac{\delta_2 \bar{\pi}^{\beta_1} \rho_1 \bar{\pi} - \rho_2 \bar{\pi} \bar{\pi}^{\beta_1}}{\beta_2 (\bar{\pi}^{\beta_2} \bar{\pi}^{\beta_1} - \delta_1 \delta_2 \bar{\pi}^{\beta_1} \bar{\pi}^{\beta_2})} \underline{\pi}^{\beta_2} + \rho_2 \underline{\pi} = S \end{cases} \quad (2)$$

with $\rho_1, \rho_2, \beta_1, \beta_2, \delta_1$ and δ_2 solely dependent on $\lambda_1, \lambda_2, \alpha_1, \alpha_2$ and r : $\rho_1 \equiv \frac{\lambda_1 + \lambda_2 + r - \alpha_2}{(r + \lambda_1 - \alpha_1)(r + \lambda_2 - \alpha_2) - \lambda_1 \lambda_2}$, $\rho_2 \equiv \frac{\lambda_1 + \lambda_2 + r - \alpha_1}{(r + \lambda_1 - \alpha_1)(r + \lambda_2 - \alpha_2) - \lambda_1 \lambda_2}$, $\delta_1 \equiv \frac{\lambda_2 + r - \alpha_2 \beta_2}{2\alpha_1 \alpha_2}$, $\delta_2 \equiv \frac{\lambda_1 + r - \alpha_1 \beta_1}{2\alpha_1 \alpha_2}$, $\beta_1 \equiv \frac{\alpha_1(r + \lambda_2) + \alpha_2(r + \lambda_1) - \sqrt{[\alpha_1(\lambda_2 + r) - \alpha_2(\lambda_1 + r)]^2 + 4\alpha_1 \alpha_2 \lambda_1 \lambda_2}}{2\alpha_1 \alpha_2}$ and $\beta_2 \equiv \frac{\alpha_1(r + \lambda_2) + \alpha_2(r + \lambda_1) + \sqrt{[\alpha_1(\lambda_2 + r) - \alpha_2(\lambda_1 + r)]^2 + 4\alpha_1 \alpha_2 \lambda_1 \lambda_2}}{2\alpha_1 \alpha_2}$.

The system in Equation 2 can be solved numerically.

4 Data gathering and parameter estimations

To estimate the upper and lower profit thresholds $\bar{\pi}$ and $\underline{\pi}$, information on the container time charter prices is necessary. With the evolution of the Harpex Shipping Index ([Harper Petersen & Co, 2015](#)) displayed in Figure 1, one can estimate the values for $\lambda_1, \lambda_2, \alpha_1$ and α_2 . For r , the standard value of 0.1 is chosen. To alter between prices and profit margins, one needs the operational cost per day, which is at the expense of the shipowner as discussed in Section 2 and can be retrieved from [Moore Stephens \(2013\)](#). Finally, the cost of buying and selling a ship can be deducted from databases composed by the UNCTAD on the basis of data from Drewry Shipping Insight.

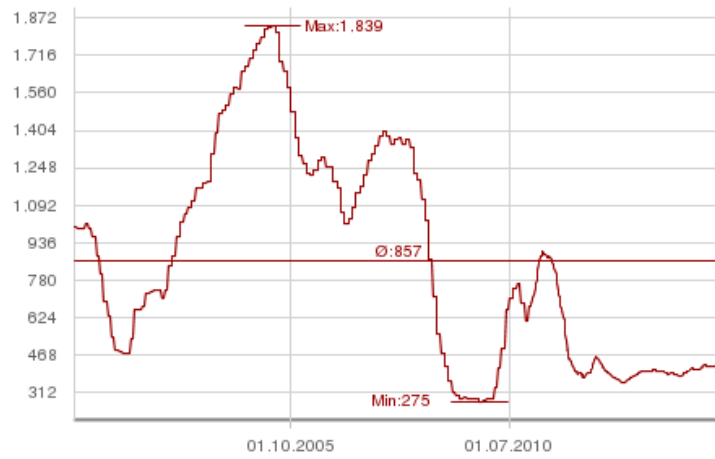
4.1 Parameter estimations

Using the evolution of the Harpex in Figure 1, estimates of $\lambda_1, \lambda_2, \alpha_1$ and α_2 can be made. It is assumed that the evolution of the individual rates for the different ship types follows in great lines the evolution of the composite Harpex, of which a longer time series is available. A first noteworthy evolution is that a genuine cyclical trend can be perceived in the period before 2000. After 2000, the container business became a booming business, up until the crisis of 2008, when rates fell drastically. As a result in that period, cycles became shorter and much more volatile. Since 2011, prices have been in a phase of recovery and

Figure 1: The evolution of the Harpex.



(a) 1986-2010



(b) 2000-2015

Source: Harper Petersen & Co (2015).

Table 1: Parameter estimates.

Parameter	Initial value	2000–2011 value	Recovery value
λ_1 (year ⁻¹)	0.67	0.70	0.50
λ_2 (year ⁻¹)	0.67	1.00	0.50
α_1	0.10	0.20	0.05
α_2	-0.10	-0.25	-0.05
r	0.1	0.1	0.1

Table 2: Cost estimates.

Variable	Value (1100 TEU)	Value (2500 TEU)
K	\$12 MM	\$25 MM
S	\$6 MM	\$12.5 MM
<i>Operational cost per day</i>	\$5310	\$5310

almost no cyclical trend is visible any more. As a result, depending on which period is used, different parameter estimates will be generated. This in turn might lead to different decision rules. For this reason, a comparison between different scenario's is required.

The estimated parameters, required to model the cyclical Markov process, are displayed in Table 1. The graphs were used to calculate the average length of each phase in the cycle. The α 's were calculated respectively as the annual growth and decline rate, according to the equation $d\Pi = \alpha\Pi dt$. Moreover, the λ 's indicate that in the 2000–2011 time frame, periods of growth on average lasted longer (1.4 years) than periods of decline (1 year). Additionally, the decline rate tended to be more severe than the growth rate, which is reflected by higher absolute values of the α 's.

4.2 Cost estimations

To have information on the costs, K , S and the *operational cost per day* are to be estimated. The values for K and S are given in million dollars. To arrive at the value for S , the value of K , retrieved from the UNCTAD, is multiplied by a fixed ratio that exists between these two values. The ratio of 0.5 can be perceived as a good approximation. Moreover, it is interesting to notice that changing the size of the considered ship only influences K and S . The evolution of the prices is the same, and the operational costs will not differ a lot, as only a few additional seamen will be required. As discussed in Section 2, fuel (an important cost driver) is not included in the time charter and has to be paid for by the merchant using the ship. As a result, the size of the ship will not influence the daily operational cost for the shipowner.

5 Results and discussion

Filling the parameters and costs from Tables 1 and 2 in the system in Equation 2 results in the entry and exit thresholds ($\bar{\pi}$ and $\underline{\pi}$) displayed in Table 3. After

dividing these values by 365 and adding \$5310, one arrives at the required thresholds (\bar{p} and \underline{p}) of the time charter day rates of a specific ship type. They are included in Table 4.

Table 3: Profit entry and exit thresholds (in million \$ per year).

	Initial situation		2000–2011		Recovery	
	$\bar{\pi}$	$\underline{\pi}$	$\bar{\pi}$	$\underline{\pi}$	$\bar{\pi}$	$\underline{\pi}$
1100 TEU	1.415	0.481	1.541	0.355	1.321	0.534
2500 TEU	2.948	1.003	3.209	0.741	2.751	1.113

Table 4: Day rates: entry and exit thresholds (in \$ per day).

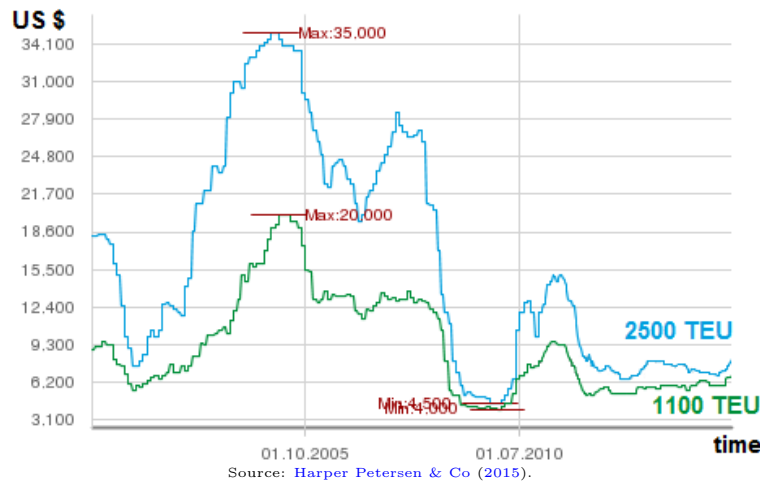
	Initial situation		2000–2011		Recovery	
	\bar{p}	\underline{p}	\bar{p}	\underline{p}	\bar{p}	\underline{p}
1100 TEU	9187	6629	9531	6284	8928	6774
2500 TEU	13388	8057	14103	7339	12848	8360

The interpretation of the results in the presented model goes as follows. For the initial case of a shipowner who wants to invest in a container ship of 1100 TEU, it is advised to wait until time charters hit the upper threshold \bar{p} of about \$9200 per day before investing if he wants to cover the variable cost and the capital cost K with the revenue from operations only. Once the lower threshold \underline{p} of about \$6600 is reached, the shipowner is advised to sell his ship and recover the redeployment value S . The reasoning is analogous for the 2500 TEU ships.

First of all, the initial situation requires some analysis. Table 4 shows that because of a higher entry cost K and higher redeployment value S , the entry and exit thresholds for a 2500 TEU shipowner are higher than those for a 1100 TEU shipowner. Nonetheless, Figure 2 confirms that the rates for bigger ships are also higher, following the positive inclination of the supply curve. A comparison of the results in Table 4 with the graph in Figure 2 learns that all thresholds from Table 4 lie within the range covered by the Harpex index. This implies that this model advises market entry or exit respectively before the top of a growth period or before the trough of a decline period is reached at realistic and attainable values. Moreover, this model shows the shipowner through entry and exit thresholds the appropriate moment of investing to cover the incurred costs with the revenue of operations, even without knowing ex-ante the turning points in the shipping cycles.

Secondly, by comparing the different scenarios, one can see that the price thresholds are more robust to Markov scenario parameter changes than the profit thresholds. This is because the operational cost, used to go from profit to price, is reasonably assumed to be fixed. This is interesting, because it are the price thresholds were a shipowner is interested in. As a result, some error margins for parameter estimation are allowed, still resulting in accurate decision rules. A comparison between the different scenarios allows to draw some conclusions regarding the influence of different parameters on the decision rules. In the 2000–2011 period, cycles are much shorter and growth and decline rates were

Figure 2: The evolution of the Harpex container time charter rates since 2000 (1100 and 2500 TEU).



higher in absolute value. This increased risk results in a higher entry threshold and a lower exit threshold when compared to the initial situation, which implies that firms will enter the market later, but will also stay longer in the market. The situation after the financial crisis with a more stable price level (hence with lower absolute values of the λ 's and α 's) is characterised by lower entry and higher exit thresholds. As a result, firms will enter the market sooner, but they will also leave the market sooner.

Finally, the sensitivity to a change of each Markov process parameter is analysed. When a growth phase lasts longer (lower λ) or is more intense (higher α), the entry and exit price thresholds \bar{p} and \underline{p} will decrease. As a result, a firm will enter the market earlier and stay longer in the market, which is reasonable. On the other hand, longer or more severe decline phases will result in increased thresholds, encouraging firms to enter the market later and leave it earlier.

6 Conclusion and future research

In this paper, market entry and exit thresholds have been estimated, based on a real options model that requires information on the evolution of cyclical markets, investment costs, redeployment values and operational costs. The results have been analysed and compared to actual values of container time charter rates. This analysis proved that the calculated values are attainable in the market and plausible. In order to further validate the results of this research on a real case, shipowners can be asked in an experiment based on interviews, if they would consider buying or selling a ship or do nothing, given certain market variables and circumstances.

Some remarks on the model as it is now presented, can be formulated. In first place, it was noted by [Stopford \(2009\)](#) that the submarkets in shipping are linked. As a result, the cost of entrance (K) and the redeployment value (S) will move along with the shipping cycles observed in the freight market. This implies that the model offers a short term decision rule, as in this time

frame the values for K and S can be assumed fixed. After a while however, when the prices in the sale and purchase market have changed, the model has to be recalculated, resulting in new entry and exit thresholds. As a second and important remark to the presented framework, one could argue that shipowners do not generate their main profits through operations, but rather by buying and selling ships against the market. This is an important extension of the present real options model that should be considered in a future version of this model.

Another possible extension of this research could be to repeat the calculations for the bulk shipping industry, a market that is supposed to be closer to perfect competition. For this market, index rates are published daily in the Baltic Dry Index. In this paper, following the approach of [Ruiz-Aliseda & Wu \(2012\)](#), the cases of new building, lay-up and scrapping are omitted, but they can be included in extended versions, as was done in the model of [Dixit, 1988](#). Another expansion of this framework can be investment lags ([Sødal, 2006](#)), which tend to occur with new building, especially in times of economic prosperity ([Stopford, 2009](#)).

The presented results could be not only important for academics and shipowners, but also for policy makers. They could use the model to more accurately predict the required capacity in ports, given actual prices and rates in the freight market.

Acknowledgements

The author wants to thank prof. dr. Hilde Meersman, prof. dr. Eddy Van de Voorde, prof. dr. Thierry Vanelslander and dr. Edwin van Hassel for their valuable help in determining the relevant market variables and data gathering.

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