Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2016/2017

Modelling Merger and Acquisition activities in container shipping market using Markov Decision Processes

by

Naouar EL KHADIRI

Copyright © Naouar EL KHADIRI

Acknowledgements

This research would not have been possible without the support and guidance of my thesis supervisor Dr. Dekker to whom I will remain indebted for all the knowledge he taught me.

To my family for their unconditional love.

Abstract

Merger and acquisition (M&A) activities in maritime sector occur in waves linked to the market cyclicality. Liners, more than ever trapped in a spiral of war prices and overcapacity, cannot sustain a viable economic base for their business, and thus are forced into a drastic corporate restructuring. This war price weighs heavily even on the most performing firms' cash flow. Maersk revenue, for instance, shrank from $61 billion in 2008 to $35.4 billion in 2016 (42% decrease), while operational costs barely dropped by 27.6%. The purpose of this paper is to address the financial and operational factors that influence the decision to engage in M&As. We chose to frame the scope of research in a 9-year period starting 2008, to capture the market whereabouts in the aftermath of the economic recession and observe how firms behave in a Cournot game environment. The reached conclusions are in line with most existing literature that investigates M&A activities in oligopolistic industries. We were able to establish the causality effect of the cost structure with flat marginal costs along with the industry shocks as key factors to influence M&As. As a result, prices and outputs change aggravating the distortion of the existing equilibrium: a second key element in this research. It establishes that a higher freight rate may not necessarily result from a suspicious collusion among firms or a growing market power but rather a rebalancing phase in the new market equilibrium. In similar circumstances to Hanjin's bankruptcy, the simulation also reveals that in the long-term, poor performing firms without niche markets will be forced out of business or swallowed in a takeover. Moreover, the simulation showed that operational synergy theory is more likely to justify M&As and that consolidation squeezes consumer surplus to the benefit of the liners but without externalities to non-merging companies. Finally, we were able to establish the little to no impact of the premium price on the decision to merge even if it exceeds the expected synergy.

Table of content

Table of figures

Table of tables

1. Introduction

1.1. Container shipping market structure

2016 was full of vivid events for container shipping industry. Historic low rates have pushed liners into deep consolidation through takeovers and strategic alliances. (Knowler 2016) observed that the number of operating liners is shrinking from twenty in 2016 to fourteen by 2018; raising anti-trust concerns. The incentives for collusion in such market conditions are substantial. (Bernheim and Whinston 1990) have established that companies who compete in multi-market contact conditions with a standardised homogeneous product, such as shipping lines, have more propensity to collude. When production input factors are set and stable for a period of time[1], agents behave in similar conditions of a Cournot-Nash model. A clear illustration of such behaviour is the fierce competition in the Asia-Europe trade lane and the two-digit number of vessels above 10.000TEU in order book per carrier.

The ongoing price war suggests that the liners' quest is to survive sluggish demand aggravated by overcapacity, rather than to build market power. Forecasts expect this capacity glut to be slowly absorbed over next two years, allowing the rates to pick up in 2019 (Bloomberg intelligence). However, the battle over ship sizes is not over yet. COSCO and CMA CGM latest orders signal that overcapacity may take longer than two years to be absorbed if no other bankruptcy in the TOP20 occurs. Even though, one may argue that market exit in the maritime industry does not contribute to supply capacity shrinkage. Unlike conventional markets, in maritime industry assets of bankrupted firms are not removed from the market. Hanjin's fleet, for instance, was chartered to a great extent and even its owned vessels were auctioned to other liners.

Period	Alliance	Partners	Market share
Starting 2014 until 2015	P3 (proposed)	Maersk Line, MSC, CMA CGM	
	CKYH Alliance	Coscon, "K" Line, Yang Ming, Hanjin	
	Grand Alliance	Hapag-Lloyd, NYK, OOCL	
	New World Alliance	APL, Hyundai, MOL	
Starting 2015 Until April 2017	2M	Maersk Line, MSC	
	CHKYE	Coscon, Evergreen, Hanjin, "K" Line, Yang Ming	
	G6	APL, Hapag-Lloyd, Hyundai, MOL, NYK, OOCL	
	Ocean Three	China Shipping, CMA CGM, UASC	
Starting April 2017	2M	Maersk Line, MSC	32%[2]
	Ocean Alliance	CMA CGM, CoscoCs, Evergreen, OOCL	26%
	THE Alliance	Hapag-Lloyd, Hanjin[3], "K" Line, MOL, NYK, Yang Ming	17%

Table 1: Timeline of liner shipping alliances. Source: consolidated from DYNALINERS TRADES REVIEW 2016

[1] Fleet capacity, the order book, the weekly services, and the routes.
[2] Not including HMM capacity (not part of the alliance)
[3] Was part of the agreement before filing for bankruptcy

In such case where the market cannot correct supply through market exit, one may be tempted to expect more bankruptcies. The remarkable isolation of Hyundai Merchant Marine (HMM) from alliances (Table 1), reflects how HMM's peers, aware of its financial distress, avoid to associate with a risky partner. HMM, Altman z-score below 0.5 as per April 2017, red flag a strong likelihood of a looming bankruptcy (Alphaliner 2017).

1.2. Merger and acquisition activities in container shipping market

Once all M&A deals are approved, by 2018 more than 60% of total TEU capacity will be detained by the TOP5. As shown in (Figure 1), this wave of mergers is by far the largest in container shipping signalling a dramatic change in the market.

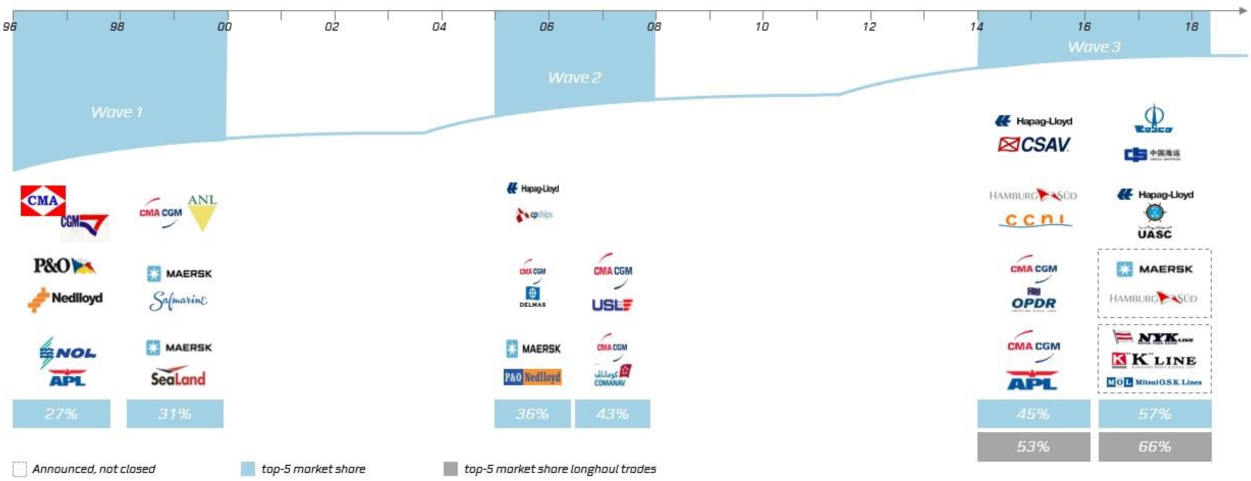


Figure 1: Latest M&A waves in container shipping industry. Before OOCL acquisition announcement. Source: (Kandelaki. 2017)

The absence of Evergreen from these consolidations, as shown in (Table 2), has cost the firm to lose substantial market share to newly established conglomerates. This latent reactivity has left Evergreen with mediocre leftovers as potential targets—namely HMM, Yang Ming and Wan Hai—in the case of a late attempt to catch up the wave.

In the other hand, COSCO, very keen to establish itself in the TOP3, has successfully engaged in a fast track growth strategy with assets acquisitions and a series of large mergers. Compared to a cautious CMA CGM who targets small businesses with niche markets such as APL and MERCOSUL.

The gain from these mergers, in the form of financial and operational synergy, is substantial. Beside acquiring relatively newer assets below book price, the acquirers ensure immediate cash inflows from the target ongoing business. The cost of capital, the WACC, is thus lowered bringing more incentives to M&A activities.

Buyer/merger	Target	Date	Type	Resulting market share
ONE (Ocean Network Express)	"K" Line, MOL, NYK	2017 (announced)	Merger	7%
COSCO	OOCL	2017 (announced)	acquisition	11.6%
Maersk	Hamburg Sud	2017 (announced)	acquisition	19%
Hapag-Lloyd	UASC	2017	Merger	8%
CMA CGM	NOL/APL	2015	acquisition	10%
COSCO	China Shipping, CSCL	2015	Merger	8%
Hapag-Lloyd	CCNI	2015	Acquisition	
Hapag-Lloyd	CSAV	2014	Merger	

Table 2: Last M&As wave among the TOP20. Source: consolidated from the press and M&As database

1.3. Problem statement and its relevance to container shipping context

Since (Nelson and National bureau of economic research (Etats-Unis) 1959), it was established that mergers are highly concentrated in time and occur in waves triggered by industry shocks. The research question **"*in a finite horizon, what is the impact of the financial status and operations' performance on the probability of merger, acquisition or market exit in container shipping sector*"**, is motivated by the latest wave of consolidation in the maritime industry in the view of the weak market fundamentals and the myopic aspect of these investments under uncertain prospect of growth.

The shadow of the spectacular financial failure of Hanjin Shipping blamed on poor management triggered interest to study the rationale of strategic decision-making in a volatile market. Any firm has to conduct investment to ensure growth. Most of these strategic investments are irreversible and therefore are riskier and more expensive. The ability to assess the effectiveness of any strategy under uncertainty is what makes or brakes the company's future. Now, in a context of overcapacity, liners can hardly achieve growth through acquiring assets. In such cases as these, external expansion becomes an attractive option to consider when targeting growth. Therefore, we intend to weigh operations' performance of selected liners against market's endogenous variables to establish the likeliness of merger occurrence by simulating the process of decision-making under uncertainty.

1.4. Paper organization

This paper is organised as follows. First, we will explore relevant literature to the research question in section "Literature Review." The purpose is to settle the academic framework of the problem statement based on existing scholarly reports. After, we will expose our approach to investigate the research question with chosen models and datasets in section "Methodology." Next, we will model the problem statement and perform adequate adjustments to fit the data. In the same section, we will proceed with simulation. Finally, in the conclusion section, we will consolidate and discuss the findings.

2. Literature Review

The fundamental concept behind any business strategy is growth. Firms can either grow organically or expand externally. (Margsiri et al. 2008) analyse the trade-off between these two strategies and establish that internal growth influences the decision to merge. (Chevalier-Roignant et al. 2011) provide an exhaustive overview of literature addressing internal investment under uncertainty. They conduct a comparative analysis of a variety of dynamic and static models for optimal capacity strategy. One interesting contribution is (Dangl 1999) who emphasises that uncertainty cause delays in irreversible projects. A statement that we will examine in later sections, since (Hackbarth and Miao 2012) define mergers as "*analogous to irreversible investment under uncertainty*."

Under an internal growth strategy, the firm focuses on acquiring assets, whereas external expansion takes place as a merger, acquisition, alliance or joint venture. (Kayo et al. 2010) investigate the reasons behind choosing to engage in either of these structures. While they noted that managers prefer to conduct M&As over alliances, they concluded that anterior studies are inconclusive as to designate which alternative creates more value to the shareholders. They have also established that firms choose alliances only when a merger is too costly and choose joint ventures whenever there is a strong opportunistic behaviour associated with a high-risk level. Some academics identify the opportunity cost as a potential decision factor. (DePamphilis 2013) states that when the stock price of the target drops below its book value, conducting an acquisition is analogue to buying undervalued assets. We find this rationale relevant to container shipping market. The cost, effort and time to acquire a fleet of new vessels and make it operational in an already over capacitated market may be consequent and risky compared to acquiring a firm that operates similar ships with existing contracts and market share.

Other literature have focused on the importance of financial synergy such as the resulting low cost of capital and tax incentives involved in the acquisition decision. (Auerbach and Reishus 1988) for instance, examined the impact of the Tax Reform Act of 1986 on merger activities and the acquirer tax benefit. He identifies the latter as the one single tax factor element that has significant economic impact on the takeover decision.

Some studies focused on the temporal dimension of M&As. (Brakman et al. 2005) established that M&As occur in waves. Their study focused on studying cross-border M&As using a General Oligopolistic Equilibrium model designed by (Neary 2003, Neary 2016). Others have tried to explain the mergers waves through business cycles. Their concern was to investigate whether the cyclicality is inherited from indigenous factors that had contributed to their occurrences. (Mitchell and Mulherin 1996) have evidenced that these waves are indeed linked to economic shocks borne by the sample industries. Although (Harford 2005) concluded that shocks are not enough to explain these waves of mergers and brought up a new factor of importance: capital liquidity. In the other hand, (Jovanovic and Rousseau 2008) observed that these waves were accompanied by a surge in market exits as shown in (Figure 2). These conclusions apply to container shipping context.

All the studies above were based on the assumption of a logical decision-making behaviour. Although, (Malmendier and Tate 2008), (Hayward and Hambrick 1997) and (Moeller et al. 2005) have questioned the rationale behind M&As. They argue—backing their position with empirical data—that most of these formations are value destructive for the shareholders and are conducted for the sake of the CEO's hubris.

Addressing the question from another perspective, (Stigler 1950) argue that firms who did not participate in an M&A may profit more from the takeover than those who did take part of it. He assumes that the ensuing synergy will not necessarily result in cost reduction and therefore the new firm's output will be less than the combined output of the initial parents. Such supply distortion will push for a surge of prices that will benefit the nonparticipant peers who did not bear the cost of the merger. However, (Cabral 2017) evidenced cases where cost efficiency was achieved after the merger and concluded that the value of nonemerging entities might increase or decrease depending on the ability of the merged entity to achieve synergy. This claim substantiates the organisational learning theory that firms acquire the knowledge to conduct mergers at lower cost through repeated experience with M&As. (Villalonga and McGahan 2005) have shown that indeed some firms behave like serial acquirers.

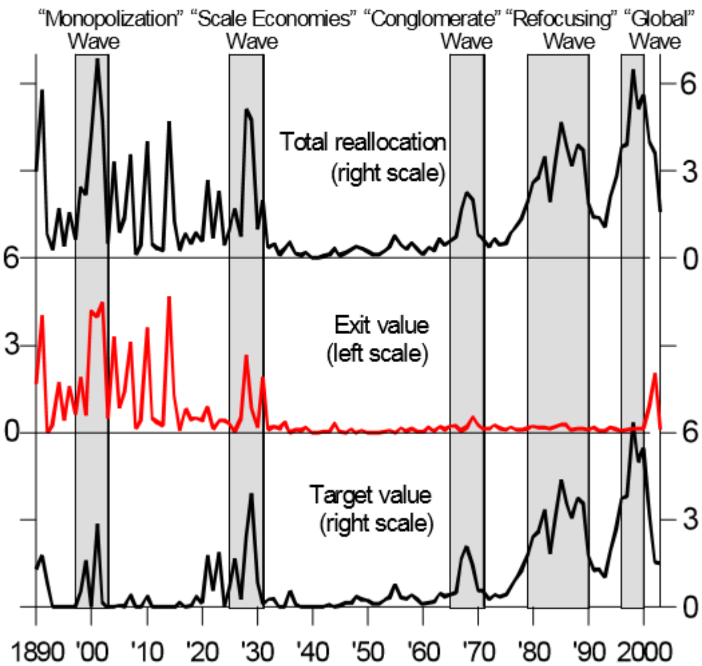


Figure 2: Merger waves, capital reallocation, capital exit value and target value in the US. Source: (Jovanovic and Rousseau 2008)

When addressing synergy, all these papers reach different conclusions. It is a non-ending debate given that no practical definition of synergy is agreed upon. (Sirower 1997) ventured an operational definition and stated *"Synergy is the increase in performance of the combined firm over what the two firms are already expected or required to accomplish as independent firms."* and set that the expected value of the merger can be formulated as follows:

$$\text{NPV} = \text{Synergy} - \text{Premium}$$

The premium is paid upfront while synergy takes time to show up in cash flows. Therefore, it is hard to evaluate a merger or to assess the decision to engage in such enterprise.

When it is not feasible for a firm to conduct M&As, (Berg et al. 1982, Reuer 1999) suggest that strategic alliances can be a compelling alternative. Reuer observes that stock market reacts, on average, positively to their announcement compared to M&As. Although, (Gomes-Casseres 2003) states that the synergy of alliances is even harder to value since partnership's gains cannot be financially distinguished from other activities.
Alliances can also, raise legal frictions with antitrust enforcers. They can be perceived as cartel formations based on strong collusion premises. The spectacular FBI raid into a meeting of the International Council of Containership Operators, commonly known as the Box Club (Paris and Page 2017) depicts the level of tension between regulators and operators. In similar conditions to the contemporary container shipping market, (Dick 2004) studied Webb-Pomerene Export Trade

Act and concluded that cartels collude not just by fixing prices by also by sharing costs (economies of density). Moreover, he suggests that some industries are *"structurally predisposed"* to collude which explain multiple cartel formation episodes. Both conclusions are easily extrapolated to the shipping industry.

When exploring literature addressing mergers in maritime industry few academic studies address the topic. (Reynaerts 2010) for instance, investigated welfare impact of mergers in the stevedoring market. He studied a particular case of Belgian stevedores, Hessenatie and Noord Natie merger. In container shipping context, (Fusillo 2009) modelled mergers using a Poisson distribution, while (Li et al. 2016) use a Stackelberg game in a two player-case[1] to simulate and assess decision-making under uncertainty.

To conclude, academics although agree on general features of market consolidation, do not reach consensus on three major points: the motives and the likelihood of mergers; their economic value to the shareholders, the rival peers and the market; and their nexus to market exit. These discrepancies can be explained by distinct sample taxonomies[2], methodologies or modelling assumptions. Our research means to bridge the gap of literature scarcity in the maritime sector along with studying the aforementioned unsettled attributes with regards to container shipping market in the aftermath of the economic recession.

[1] Maersk and MSC

[2] Different Industry types and temporal scope of the samples

3. Methodology

3.1. Problem description and Modelling

The objective of this paper is to assess how operation performance impacts the decision to merge. To address this topic, we will investigate the financials of the global carriers that reflect their operations management performance. The latter is captured through both their production function and cost function. The state of the world must be stochastic to mimic market uncertainty. Therefore, we will need an adequate econometric model to fit the carriers' production function given a stochastic market configuration. The econometric model of container shipping industry will be addressed in the section "Mergers and Acquisitions' Econometric Model".

The output of this econometric model will be used as input for an algorithm that simulates a decision-making process under uncertainty. The output of such algorithm must be the decision to either merge or not. The algorithm must design the market as a stochastic dynamic process evolving in a finite horizon. Contrary to existing literature addressing M&As, the problem statement is not interested in the long run equilibrium and frame the scope of research in a finite horizon. Most management boards set and conduct quinquennial strategies. Therefore, in this paper, all economic activities are assumed to take place in a finite horizon $[0, T]$, the iteration horizon of the algorithm.

Moreover, to mimic the myopic visibility of the decision maker, the algorithm must follow a greedy strategy. Firms do not enjoy full visibility of the market behaviour over time. Therefore, their decisions are based on future expectations given the present state of the world (partial visibility). In that sense, the algorithm should produce an output in iteration $t = \tau$ given the information available at that time only[1]. This type of algorithm is called greedy algorithm. In the next section, we will address an adequate algorithm to solve the problem statement.

3.2. Markov Decision Process

After considering different stochastic process models, we resolve to investigate the research question using Markov Decision Process (MDP).

A Markov process is a stochastic process that obeys to Markov property: *"The effects of an action taken in a state depend only on that state and not on the prior history."* Mathematically expressed by:

$$P(S_{t+1} = s' | S_t = s_t, A_t = a_t, S_{t-1} = s_{t-1}, A_{t-1} = a_{t-1}, \dots S_0 = s_0) = P(S_{t+1} = s' | S_t = s_t, A_t = a_t)$$

A memoryless process which is a close representation of the random walk in financial markets. The motivation behind this choice is that the question research addresses the outcome of a decision-making process given a state of the world with optimisation purpose. The intention to mimic a stochastic market to model uncertainty, makes the MDP the most suitable model to provide robust and realistic outcomes. Other models are static and do not allow for simulation: a key element to a proper assessment.

The success of MDP in Artificial Intelligence (AI) with reinforcement learning algorithms, stock markets' portfolio management and communication networks, is due to its accuracy to modelling complex problems under uncertainty with cost efficiency. Problems such as the gambler's ruin, the multi-stand forest management problem in (Garcia and Sabbadin 2001) or simply evaluating the performance of sports professionals (Routley 2015) are *"easily"* and efficiently solved using MDP modelling.

[1] The market settings are stochastic and change in each iteration and firms cannot predict these settings beyond iteration $t = \tau$. This condition is referred to as myopic visibility of the market.

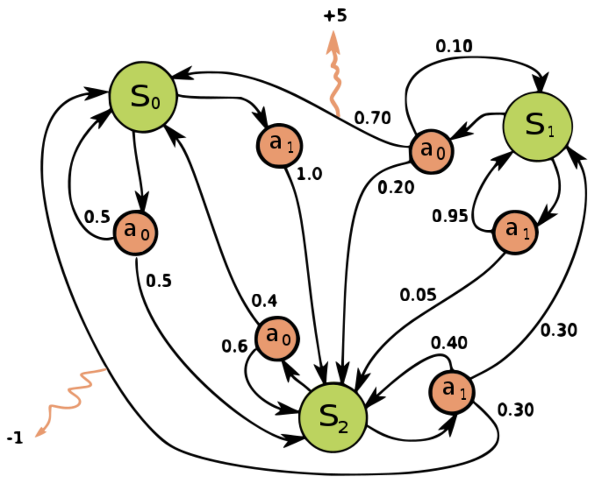


Figure 3: Example of a Markov Decision Process where the green circles are states, the orange circles are actions with associated probabilities, and the orange arrows are rewards.

In this research, following (Puterman 2014), we define the discrete-time Markov Decision Process by the tuple:

$$MDP = \langle \mathrm{S}, \mathrm{A}, \mathrm{P}, \mathrm{R}, \gamma \rangle$$

A sequential decision problem with a Markovian[1] transition model and additive rewards, where:

- The state space must be finite: $S = \{small\ firm\ ; large\ firm; merger; bankrupted\ firm\}$; when the process is in state s at time t we note $S_t = s$
- The action space[2] $A = \{merge; acquire\ ; stay - put\ \}$; the process is assumed to be controlled by a decision maker who chooses an action $a \in A$. In our case, the set of possible actions is invariant over time.

The "merge" action is undertaken when two firms with the same size consolidate. The "acquire" action is carried out when a large firm takes over a small firm. The "stay-put" action is when a firm follows an organic growth strategy. All possible actions are analogous to an ISD policy. A set of finite actions is defined as a policy (π).

- The transition probabilities $P^a_{ss'}$ to go from one state (s) to another (s′), given an action (a): $P^a_{ss'}$: S × A → Pr(s'|s,a). For $\forall a \in A$, the transition probability matrix will have the following general format:

$$\begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Such that for each row i we have $\sum_j p_{ij} = 1$. Note that for the "bankrupted firm" state, whatever the action taken, the firm will remain in that state. It is called an absorbing state. Therefore, we have a deterministic transition vector $[0 \quad 0 \quad 0 \quad 1]$ for the "bankrupted firm" state.

- The reward matrix $R^a_S = \mathbb{E}\ [R_{t+1} \mid S_{tate} = s, A_{ction} = a]$. Given the state of the system and the chosen action, a reward or penalty is incurred. It is the measure of performance that drives the optimisation problem.

---

[1] Obeys to Markov property defined previously.

[2]"Engage into alliance" and "split" are possible actions within the action space. However, they will not be addressed in this research—reasons: quantitative literature scarcity. We could not find an appropriate model and resolves that further research is needed to address them properly.

- The discount factor $\gamma \in]0;1[$ is used to bootstrap the value of future rewards. Although it is possible to model un-discounted MDPs, we prefer to follow the financial practice in merger evaluation, where a discounted factor is applied.

Firms' objective to maximise the expected net present value, can be associated with a greedy strategy since the decision makers have myopic visibility of the market.

Therefore, the model's objective is to find the optimal policy (π^*) that maximises the state value function $Max\ V_\pi(s)$ (the sum of all rewards of the state (s) following a policy π):

$$\pi^* = arg\ max_{a \in A}\ V_\pi(s)$$
$$with\ V_\pi(s) = \mathrm{E}\left[\sum_{k=0}^{\infty} \gamma^k * R_{t+k+1} \mid S_t = \mathrm{s}\right]$$

We simplify the value function as follows:

$$V_\pi(s) = \mathrm{E}[R_{t+1} + \gamma * V_\pi(S_{t+1}) \mid S_t = \mathrm{s}]$$

$$V_\pi(s) = R_s + \gamma * P_{ss'}^a * V_\pi(s') \quad (1)$$

Equation (1) can be expressed as a Bellman Equation and thus easily solved using Dynamic Programming algorithm (DP). (Puterman 2014) has established the model will converge to one optimal solution given Bellman's principle of optimality and the MDP theorem:

- There exists an optimal policy π^* that is better than or equal to all other policies, $\pi^* \geq \pi$, $\forall\pi$
- All optimal policies achieve the optimal value function, $V_{\pi*}(s) = V_*(s)$

To solve the Bellman equation, we need to define the reward matrix R_s and the transition probabilities matrix $P_{ss'}^a$. For the discount factor γ, we will refer to existing literature addressing investment in shipping and the common practice in the industry.

As stated in the problem definition, the objective value function is defined as the expected net present value. Hence, the instant reward R_s would be the instant profit realized at state (s). Since this research aims to mimic firms' behaviour in life-like market conditions, we will need to build a multi-agent MDP[1]. Therefore, the reward matrix and the transition probability of each firm should be estimated assuming that each agent makes his decision independently.

To produce literate estimates for $P_{ss'}^a$ and R_s we decide to rely on reliable literature to come up with a suitable econometric model for the container shipping market. Fortunately, we were able to single out some relevant researches that will be discussed in the next section.

It is worth mentioning though, that other possibilities are available to estimate these values such as a Monte Carlo simulation (POMDP). However, the problem definition is focused on how operational performance and financial condition influence the decision to merge.

3.3. Mergers and Acquisitions' Econometric Model

Financial literature is rich of attempts to model M&As. (Perry and Porter 1985), (Palepu 1986), (Auerbach and Reishus 1988), (Hall 1988), (Lambrecht 2004) and (Hackbarth and Miao 2012) propose relevant models to portray oligopolies' merger activities.

Although all these models have similar theory base, in this paper, we will focus on (Perry and Porter 1985, Hackbarth and Miao 2012).

[1] We will design an MDP for each firm to maximize its own NPV.

(Hackbarth and Miao 2012) study merger likelihood and timing in an oligopolistic industry. They apply a real option model at market equilibrium conditions and use stochastic endogenous variables to replicate demand shocks. They established that mergers are more likely in industries with high dispersion in firms' size and that a higher level of competition in the market results in delays in the timing of mergers. They also conclude that small merging firms benefit the most when merger costs are similar and suggest that non-merging firms may also profit in a highly concentrated market.

Considering the relevance of the modelling and findings of (Hackbarth and Miao 2012) to our framework, we, therefore, decide to apply a similar approach. The reason behind this choice is that (Perry and Porter 1985) only examine the scenario where small firms merge into a large firm. While the theory and the reasoning in (Hackbarth and Miao 2012) are identical, they extend their work to include the scenario where a large firm takes over a small firm. A scenario that is of great interest to us in this paper. Also, their use of the geometric Brownian motion to model the random walk in price demand as a stochastic entry is in line with our framework to model a stochastic market. However, we will not restrain our model to the specific cost structure they apply for simplification. For that, we decide to use (Perry and Porter 1985) general cost structure[1].

In the following subsections, we will introduce major notions and aspects of mergers that will be needed to design the econometric model.

3.3.1. The scenarios

(Brealey et al. 2012) classify M&A activities based on integration types. The consolidation type is when both companies terminate their legal existence, and a new company is created. The statutory merger type is a takeover where one company ceases to exist. Assets and liabilities' ownership transfers to the acquiring parties.

To mimic container shipping industry and for practicality reasons, we design a market with n identical large firms (oligopolies) and m identical small firms. The supply of capital is fixed overtime hence no entry nor exit: $\sum_i k_i = nk_{Large} + mk_{Small} = K$ where K is the total amount of capital available in the market.

This setting will be relaxed in the second phase of the simulation to allow for market exit scenario. To avoid a cumbersome model, the capital of large firms is set to equal twice the capital of small firms: $k_{Large} = 2 * k_{Small} = k$

Case scenario: symmetric merger between two small firms

The number of large firms grows by one while the number of small firms diminishes by two:

$$(n+1)k + \left(\frac{m-2}{2}\right)k = K$$

Case scenario: asymmetric merger between a large firm and a small firm

The two-type firm structure is destroyed: the market is formed by $n-1$ identical large oligopolies, $m-1$ identical small firms and one extra-large firm with a capital equals to $\frac{3}{2}k$.

$$\frac{3}{2}k + (n-1)k + \left(\frac{m-1}{2}\right)k = K$$

[1] The cost function in (Hackbarth and Miao 2012) is a special case of (Perry and Porter 1985) cost structure.

As previously mentioned, we prefer to maintain the two-player structure of the market for practicality reasons. Therefore, in the case of an asymmetric merger, we will assume that the merged firm will have the same capital as the large firm. In our game design, the maximally allowed capital per firm is k.

Case scenario: symmetric merger between two large firms
This case is not addressed since we assume anti-trust laws forbid such formation, and therefore, it is not subject to a decision-making process.

3.3.2. The merger valuation

The gain (or loss) from M&As is defined by $merger\ surplus = synergy - merger\ costs$ where merger costs (noted hereafter by C_m) are mainly the premium paid to the target shareholders, and synergy is defined by the expected mark up in future value of the merged firms (noted hereafter by V_m) compared to their stand-alone values (noted hereafter by $V_i\ and\ V_j$)[1]. We have then, the NPV of the merger surplus of firm i and firm j:

$$NVP = V_m - V_i - V_j - C_m \qquad (2)$$

We define the value of a firm i at $t = \tau$ by[2]:

$$V_i^\tau = \mathrm{E}^\tau\left[\sum_{j=0}^{\infty} \frac{\pi_i(\tau + j)}{(1 + r)^j}\right]$$

And the profit π_i of the firm i is:

$$\pi_i = P * q_i - C(q_i, k_i)$$

In the case where the value of the merged entity post-merger equals the sum the two firms' value pre-merger $V_m = V_i + V_j$, the merger surplus would be negative and equals the lost costs incurred during the merger operation $NVP = -C_m$. From the market's perspective, such scenario has no economic basis and firms are better off in a stand-alone formation. However, firms value individually the return of the merger decision and tend to exaggerate the premium paid C_m to signal their belief of high expected synergy.
(Davidson 1985) states that a firm i acquiring a firm j is willing to pay $V_m - V_i$ as a maximum and that firm j is willing to accept V_j as a minimum. It follows that for a merger to happen and keeping in mind the acquiring firm is the one who bears merger costs[3], C_m must verify:

$$V_j \leq V_j + C_m \leq V_m - V_i$$

Where $V_j + C_m$ is the takeover price (Baldi and Trigeorgis).

If the acquiring firm does not achieve a merger surplus exceeding the stand-alone value of the target plus the premium, the merger in question results in value destruction for the shareholders. Such scenario can only be explained by hubris and agency theory. In this paper, we will not address these possibilities, and we will assume that firms are rational decision-makers.

---

[1] We assume no salvage costs, although it is a common practice for the acquirer to sell some of the target's assets after the takeover. Compared to the NPV, these salvage costs are negligible.

[2] This is a discreet valuation. For a continuous value in time we have $V_i^\tau(t) = \mathrm{E}^\tau\left[\int_0^\infty e^{-rt}\pi_i(t)dt\right]$

[3] In real life the target also incur costs in the form of advisory service fees. These costs are addressed in "the cost to merge" section.

3.3.3. The discount factor

The discount factor is added to reflect the time value of the money while assessing policies. (Powell 2011) mentions that an MDP discount rate has the following format $\gamma = \frac{1}{1+r}$ where r is the interest rate. We prefer to adopt the common practice in mergers and use the weighted average cost of capital (WACC) instead of the interest rate. (Mukherjee et al. 2004) established in a survey addressed to CFOs1, that firms prefer to use their own WACC to value mergers. CMA CGM, for instance, while assessing NOL merger used a range of WACCs between 9% and 14% explaining that APL capital structure is not different than theirs.

We find these values are in accordance with most literature addressing investment in the maritime sector. For instance, (Greenwood and Hanson 2014) used a value of 13% and (Sødal et al. 2008) studied a range of values $[0.05; 0.20]$ with a special focus on a discount rate of 10%. (Li et al. 2016) also, set up a discount rate at 0.89 using an interest rate of 12%. Other papers use the value 11.5%.

From above, we observe a quasi-consensus over the range [9%;14%] and therefore, in the section “Simulation and Findings” we shall use this range to define the discount factor.

3.3.4. The cost to merge

Transaction costs of M&As for legal and financial advisory fees apply to all M&A activities in all sectors. (Chahine and Ismail 2009) report that these administrative fees roughly account for 1.15% of the merger deal. We judge they have little to no impact on the decision to merge. Therefore, they will not be addressed in this paper. We will rather focus on the premium paid by the acquirer to the target as the main source of cost during M&As.

3.3.5. The assumptions

To model incentives to merge, (Hackbarth and Miao 2012) and other scholars had to make some organic assumptions for the sake of “*analytical tractability*.” For instance, since there are two rational incentives to merge—gaining market power or/and reducing costs (economies of scale)—(Perry and Porter 1985, Hackbarth and Miao 2012) assume stability growth—the Inada conditions—and constant return of scale $xY = F(xK, xZ)$ where Y is the output, K is the capital and Z is any other production input such as labour or technology.

The constant return of scale assumption may be challenging to prove in the context of container shipping since it relies entirely on the formulation of both the production function and the cost function. Empirical studies have demonstrated that output elasticities of human and physical capital in a Cobb-Douglas production function are both equal to 0.5. As a result, most scholars including (Hackbarth and Miao 2012), design their models with the function $q = \sqrt{kz}$. Not an anodyne choice since this equation checks for constant return to scale and for decreasing returns to either factors taken alone. Moreover, this production function allows for the cost function to be expressed in a quadratic formula. Quadratic formulas are known to allow for a great flexibility in approximating smooth concave curves such as costs according to (Markowitz 1952). (Aguerrevere 2003) mentions that the use of a quadratic cost function and its associated linear marginal cost curve has been inherited from early empirical studies of the British electrical industry such as (Green and Newbery 1992). Although, (Bertola and Caballero 1990) questioned its validity and discussed its limitations. In this paper, we will investigate if indeed the container shipping market has a quadratic cost function.

As a result of the quadratic cost function, (Perry and Porter 1985, Hackbarth and Miao 2012) were compelled to assume that firms cannot grow organically but only through takeovers and that the

[1] of 701 US firms engaged in M&As during the period 1990-2001

amount of total capital in the market is constant over time. The reason is that if the total amount of capital is variable over time, it would be mathematically challenging to compute outputs and prices at equilibrium. Thus, for mathematical practicality, they set the capital as constant over time.

3.4. Dataset Description

In the following subsections, we will define the data we need to build the model. To capture the market we need the yearly prices, the elasticity and the total demand. For the merger valuation and since (Hackbarth and Miao 2012) use a quadratic cost function, for each firm we need the operations' costs, the number of containers transported (quantity of container slots sold) and the enterprise value to model the capital. At first, firms' revenue is not needed in the model, but as we deepen our analysis, we will need to use the revenues as proxy.

3.4.1. The source

In this paper, we will only rely on well-known and accurate databases such as:

Thomson One	financial data and M&A data
Bloomberg	financial data of the public container shipping firms
Clarkson	Reliable database for shipping market

Table 3: a listing of database sources

We will also rely on peer reviewed literature and the yearly financial reports of all studied firms starting 2008.

3.4.2. The scope

For the financial data, we will use the time scope of the research, starting 2008 ending 2016, for the hypothesis test of the cost function.
Firms that operate in container shipping but base their business model on chartering—such as SeaSpan Corp and Danaos Corp—will be excluded. These companies have a different production function which does not depend on container slots sold but on the number of chartered days.
And finally, we will enlarge the scope starting 1996, to model the inverse production function in container shipping market using the world container export from Clarkson database. We do so to produce a well-fitting model for demand in the long run.

3.4.3. The variables

Below the description of external variables with their sources.

Source	Data code	Label	Type	Database field ID	Third party audit
ThomsonOne (Reuters)	C(t)	Operating expense	Currency ('000 000 $)	ETOE	Yes
	R	Total Revenue	Currency ('000 000 $)	RTLR	Yes
	k	Enterprise value	Currency ('000 000 $)		NO (Reuters estimate)
Bloomberg	q	FFE[1] slot sold	Unit (FFE =TEU/2)[2]	FS941	No (firm's estimate)
Annual financial reports	P	price (annual average)	Currency ($/FFE)		No (firm's estimate)

[1] Forty foot equivalent container (40' ft)
[2] We model q per FFE since the price is per FFE. Therefore, the number of TEUs in Bloomberg is divided by 2.

Alphaliner		TEU capacity	Unit (TEU)	TOP100	NO (Alphaliner's estimate)
Clarkson database	Q	Total demand	Unit ('000.000 TEU)	World Container Exports	NO (Clarkson's estimate)

Table 4: a listing of variables, their sources and description.

4. Simulation and Results

4.1. Parameter Estimates

In this section, we will estimate the econometric model parameters and its endogenous variables. The purpose is to be able to simulate the market and mergers in a life-like environment. For that sake, we will challenge a set of assumptions and simplifications the model is based upon to assess its relevance to container shipping context. To use (Hackbarth and Miao 2012) we need to assume an oligopolistic industry. Therefore, in the first sub-section, we will instigate if the container shipping industry is indeed an oligopolistic market. After, in the second sub-section, we will challenge the quadratic cost assumption of their model. Following the result of these two subsections, we will adapt the econometric model of (Hackbarth and Miao 2012) to container shipping context in the third subsection.

4.1.1. Oligopoly Assumption

All models reviewed in this research address an oligopolistic market structure. In the context of container shipping, it is widely assumed to be the case[1]. However, the nature of the business makes it difficult to prove the validity of this assumption. The use the Herfindahl–Hirschman Index (HHI) either on TEU capacity, the number of operating ships or the revenue as proxies to market share, reveals divergent interpretations based on analysts' subjective segmentation of the market. Firms operating in ocean shipping and short sea and feeders are regularly mixed up. The TOP100 report of (Alphaliner.)[2] for instance, which includes both these two categories, may suggest a competitive market using reported TEU capacities (HHI=899)[3]. Furthermore, even if we exclude the short sea and feeder companies and consider only the TOP16—carriers with relevant international ocean shipping activity—the index shows a relative concentration but not significant enough to raise anti-trust concerns (HHI=1141). However, once we include the alliance formations[4], the score rises significantly to indicate a highly concentrated market (HHI=10000). This score indicates that each alliance is large enough as to influence the market. We, therefore conclude that container shipping market, even though it appears fragmented, features an oligopolistic behaviour.

4.1.2. Cost Function Hypothesis Test

To conduct a hypothesis test on the cost function, we must assume that no technological progress has occurred during the research time scope. Although it is debatable whether to consider slow steaming and vessel over 18000TEU as technological progress that distorted the liners' production function, we consider that the time scope of the data limits such distortion.

---

[1] See for instance (Sys 2009) and (Rau and Spinler 2016)

[2] See Annex B

[3] $HHI = 10.000\left[\sum_i (\frac{TEU\ capacity\ of\ firm\ i}{total\ TEU\ capacity\ in\ the\ marker})^2\right]$ where i indexes firms. See U.S. Department of Justice and the Federal Trade Commission Horizontal Merger Guidelines 2010.

[4] in the Alphaliner TOP100

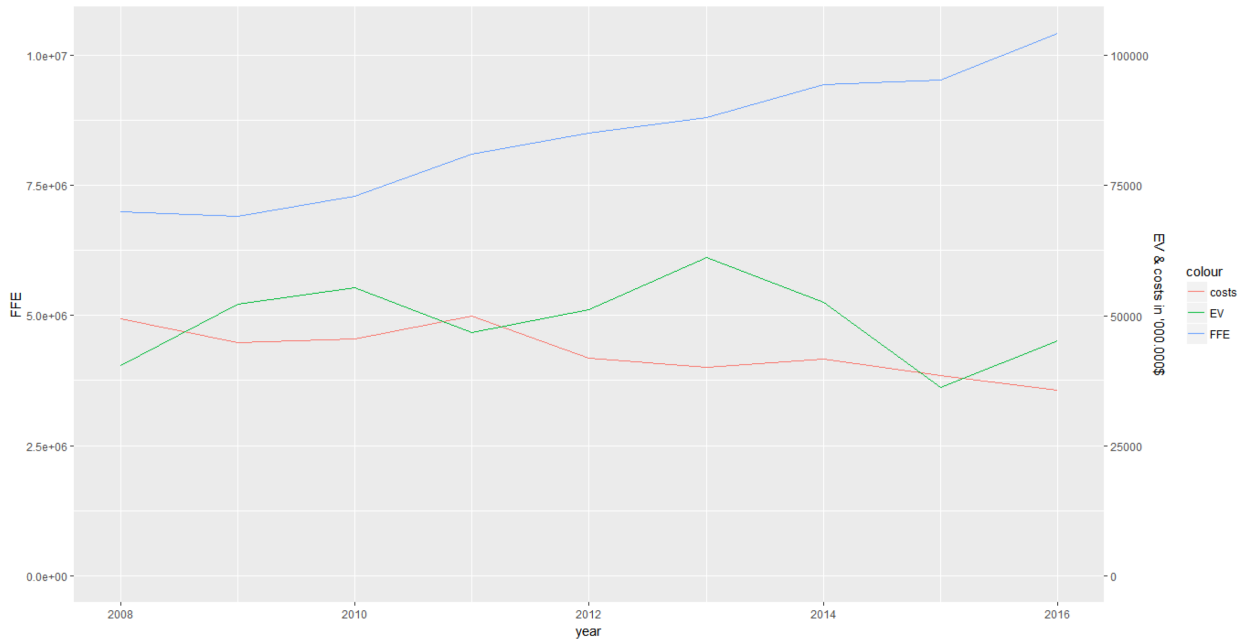


Figure 4: Maersk data - costs, FFE and Enterprise value. See the dataset description for sources and units

We conduct an OLS regression analysis on logarithmic entries from Maersk data[1] (Figure 4). The cost function $C(q,k) = \frac{1}{2} * \frac{q^2}{k}$ is then rewritten in a logarithmic expression:

$$\ln(C) = \ln\frac{1}{2} + 2\ln q - \ln k$$

The estimate values of Maersk FFE slots sold seem to harm the model's performance[2] (R^2=69.6%; P-value=0.028). Therefore, we consider the use of a proxy to capture the value of the FFE slot sold (q) into the model. For that sake, the revenue entry as a proxy seems relevant[3]. Although the annual average price is not an accurate entry and may not be significant in the model. It is a rough estimate given by Maersk in its annual financial report[4] given that each lane has it own price that evolves over time.

The new logarithmic expression of the costs is then formulated as follows[5]:

$$\ln(C) = \ln\frac{1}{2} + 2\ln R - 2\ln P - \ln k \qquad (3)$$

The second OLS analysis shows a satisfactory level of performance (R^2=98.8% and p-value≈3,28e^{-5}) with the correct signs for the coefficients' estimates (Figure 5). The plot "Residuals vs Fitted" exhibits the residual errors plotted versus their fitted values. The residuals should be randomly distributed around the horizontal line representing a residual error of zero with no distinct trend in the dispersion of points. We consider this assumption to hold since the red line which displays the average value of the residuals at each fitted value, moves in the small interval $]-0.01; 0.01[$. The absence of an outstanding trend can also be inferred from the scale-location plot which represents the square root of the relative error as a function of the fitted values.

---

1 See Annex A section 1.
2 In Maersk annual report 2016, the sensitivity for container freight volume is ±100000 FFE. See Annex A section 2.
3 In the annual statements, the revenue entry is audited by third parties, while the number of TEUs moved is a rough estimate given by Maersk (not verified by a third party).
4 In Maersk annual report 2016, the sensitivity for container freight rate is ±$100/FFE
5 Using $Revenue_{annual} = \sum_j P_j * q_j \approx P * \sum_j q_j$ with j indexing days in a year.

We also observe that the residual errors' distribution in the standard Q-Q plot, is roughly normally distributed. Finally, a good regression model should have few outliners. The last graph shows each observation's leverage—its weight in the model's fitness. Observations with Smaller Cook's distance means that removing them has little effect on the regression results. Observations with distances larger than 1 suggest the presence of possible outliers. Even though 2011 data is approaching the value 1, we conclude that our model is moderately acceptable.

While the model fits and validates global linear assumptions[1], we notice that the coefficients do not approximate the intended values as per equation (3). More precisely, the revenue coefficient[2] suggests that the cost C(q,k) and the revenue R (and therefore q) may have the same order of power. We conduct a Wald test h0: coefficient of Log_revenue = 2. The outcome is to reject the null hypothesis (F=169.31 and p-value=$4.78e^{-5}$). However, when we conduct a similar test h0: coefficient of Log_revenue = 1. The outcome fails to reject the null hypothesis (F= 0.5089 and p-value= 0.5075). We therefore, conclude that the cost function has the same order as the revenue and thus, the cost function is linear with regards to the quantity sold.

In other words, since 2008, Maersk's cost function is not a quadratic function but instead, has a flat marginal cost. This finding violates (Hackbarth and Miao 2012) assumption on the cost function structure.

To investigate further this result, we conduct a similar analysis on peers[3]. (Figure 6) and (Figure 7), display logarithmic values for costs and revenue of selected carriers. All liners have their logarithmic costs and revenue values almost aligned on the logarithmic 45° line with (R^2=99% and p-value<$1e^{-5}$). Only Maersk depicts a slight outline behaviour showing an exceptional performance in the form of low marginal costs.

It is important to clarify that by flat marginal costs, we do not imply fixed over time but rather independent from the quantity of FFE slot sold. In that sense, since the second derivative of costs by quantity is null, we infer that marginal costs are constant with regards to quantity. This configuration reflects a mature industry.

[1] normal distribution of errors, linearity, homoscedasticity and non-collinearity
[2] The CI of the revenue coefficient at 95% confidence is [0.7329805 ; 1.1510117] is significantly $\ll 2$
[3] See Annex A section 3

```
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept)  5.45475    1.74287   3.130  0.02596 *
log_revenue  0.94200    0.08131  11.585 8.41e-05 ***
log_EV      -0.05862    0.03516  -1.667  0.15632
log_price   -0.34576    0.07977  -4.334  0.00747 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01559 on 5 degrees of freedom
Multiple R-squared:  0.9879,    Adjusted R-squared:  0.9806
F-statistic: 135.8 on 3 and 5 DF,  p-value: 3.283e-05


ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
Level of Significance =  0.05

                      Value  p-value                   Decision
Global Stat        9.0550628 0.059738    Assumptions acceptable.
Skewness           0.8720705 0.350383    Assumptions acceptable.
Kurtosis           0.0001129 0.991521    Assumptions acceptable.
Link Function      7.3088711 0.006862 Assumptions NOT satisfied!
Heteroscedasticity 0.8740083 0.349848    Assumptions acceptable.
```

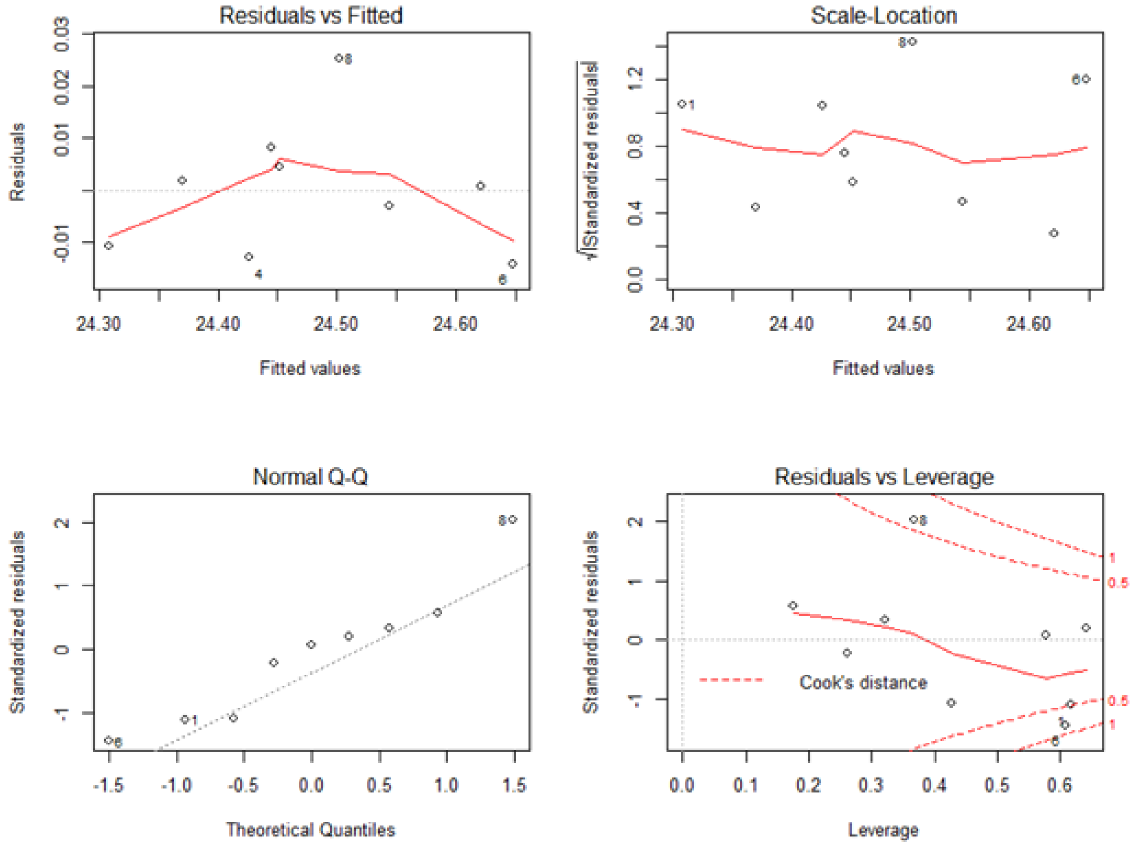


Figure 5: logarithmic linear regression analysis on Maersk data

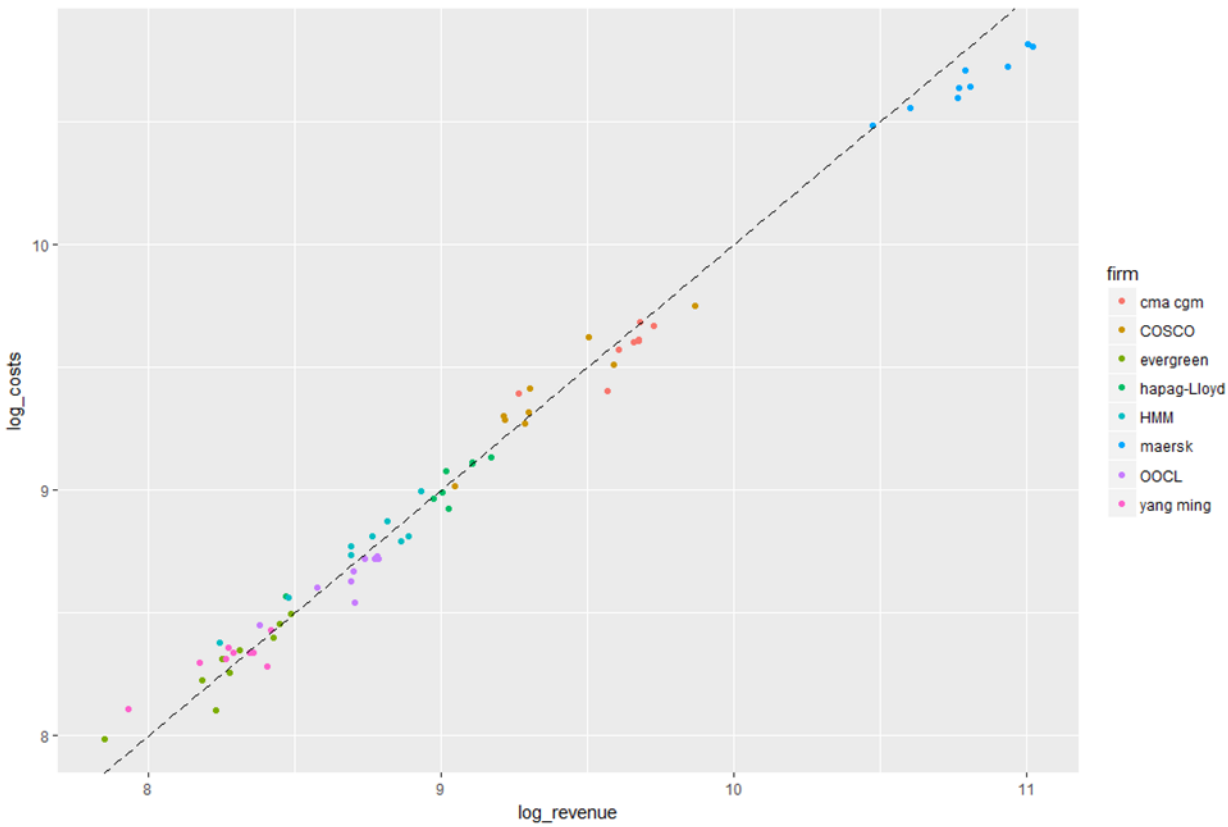


Figure 6: logarithmic values of costs and revenues of selected liners plotted against the logarithmic 45° line. Data in annexe D.

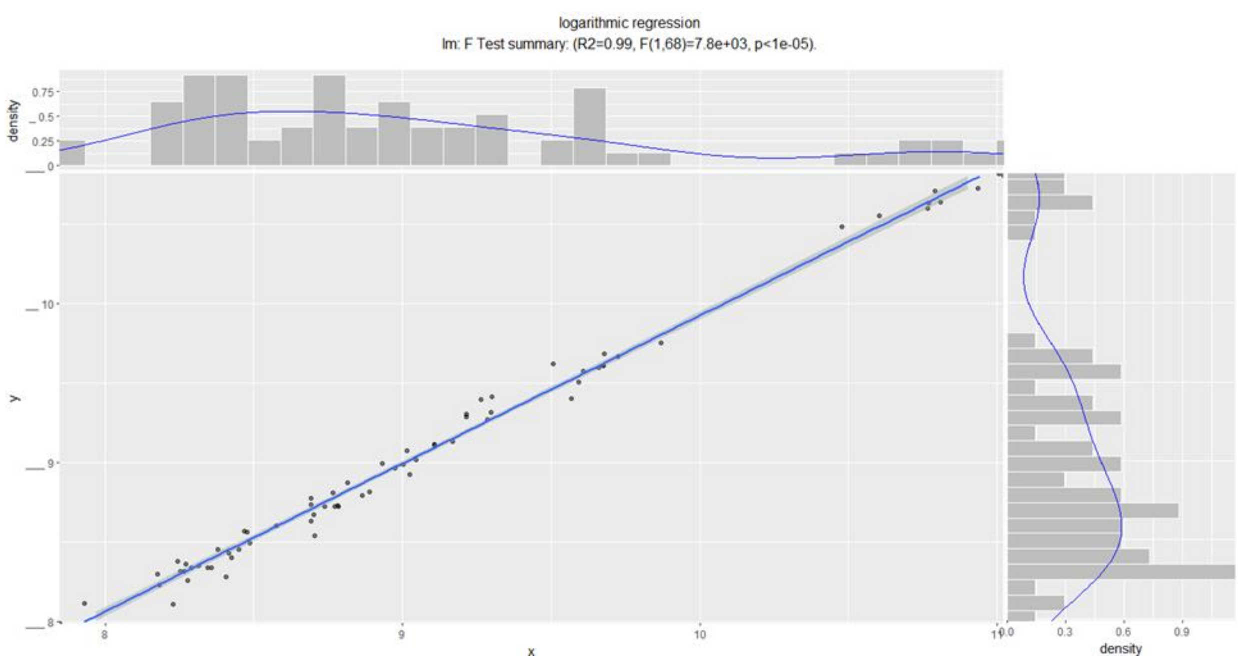


Figure 7: linear regression analysis on the log values of cost and revenue of all firms with marginal distributions.

4.1.3. Model Adjustment

4.1.3.1. Cost structure

Following the cost function assumption violation, we need to adapt the econometric model to the container shipping context. Since (Hackbarth and Miao 2012) based their work on (Perry and Porter 1985) and studied a special case of cost structure from Perry and Porter's general model:

$$C(q,k) = k * g + d * q + \frac{e}{2k}q^2.$$

With d the marginal cost and g the fraction of the capital that generates the fixed costs. In the previous section, we established that the cost function is not quadratic hence $e = 0$. By the same means, we found $g = 0$ (p-value=2.9.e^{-9} and R^2=98.99%). It follows that fixed costs and sunk costs are negligible compared to variable costs. Knowing that all studied liners have expected deliveries in the order book, these results support the notion of abundant and cheap capital[1] sources to finance operating assets between 2008 and 2016.

We therefore, drop the entry k from the previous notation and we rewrite the cost function as follows:

$$C(q) = d * q$$

(Choudhury 1994) established that large firms incur lower marginal costs compared to smaller firms[2]. Therefore, for the n identical oligopolies we set $d = c_l$ and for the m identical small firms we set $d = c_s$ with $c_s > c_l$. Since marginal costs do not decrease perpetually and must reach some minima where a firm can no longer improve its operations given a defined capital, we set c_l to be that minimum. Therefore, no synergy is possible beyond that limit. Merger in this scenario will not profit from economies of scale.

4.1.3.2. Price and outputs

Since all liners are price takers[3] and behave in a Cournot game, at equilibrium, each firm maximises its profit function $\max_{q_i(t)} \pi_i(\tau)$. We then, use the first order to define the optimum $q_i^*(t)$:

$$\frac{\partial \pi_i}{\partial q_i} = 0$$

$$\Rightarrow \frac{\partial (P * q_i)}{\partial q_i} - d = 0$$

Using the inverse demand function:

$$P = a - b * Q \qquad (4)$$

With $Q = \sum_{i=1}^{i=n+m} q_i$ the total output of all firms in the market.

It follows:

$$\Rightarrow \frac{\partial\left[\left(a - b * \sum_{j \neq i} q_j - b * q_i\right) * q_i\right]}{\partial q_i} - d = 0$$

---

[1] due to historic low interest rates

[2] Approximate marginal costs as a percentage of the average FFE price perceived by each firm (average over 9-year period): Maersk 54% – CMA CGM 66% – Hapag-Lloyd 85% – COSCO 76.8% – HMM 82% – OOCL 66% - EVERGREEN 85.7%. These performances can be explained by economies of scale and a better utilization rate of assets (for instance large procurement contracts or maintenance contracts results in lower cost per unit produced). Maersk has the best operations' performance. Also noticeable in Figure 6

[3] As detailed in the introduction.

$$\Rightarrow \frac{\partial\left[(a - b * \sum_{j\neq i} q_j) * q_i - b * q_i^2\right]}{\partial q_i} - d = 0$$

$$\Rightarrow (a - b * \sum_{j\neq i} q_j) - 2b * q_i - d = 0$$

$$\Rightarrow a - b * \sum_{j} q_j - b * q_i - d = 0$$

Hence the optimum quantity for a firm i to produce at equilibrium is

$$q_i^* = \frac{P - d}{b} \qquad (5)$$

With n identical oligopolies and m identical small firms and their respective marginal costs $c_l \; and \; c_s$, the total output of the industry at $t = \tau$ is

$$Q = \sum_{i=1}^{n+m} q_i^* = nq_l^* + mq_s^*$$

$$\Rightarrow Q = n * \frac{P - c_l}{b} + m * \frac{P - c_s}{b}$$

Let $B = n + m$ be the number of firms in the market. We have then $m = B - n$, it follows that:

$$Q = \frac{(B - n)(P - c_s) + n(c_s - c_l)}{b}$$

$$\Rightarrow \frac{b * Q(\tau) - n(c_s - c_l)}{B} = P - c_s$$

$$\Rightarrow \frac{b * Q - n(c_s - c_l)}{B} = a - b * \; Q - c_s$$

$$\Rightarrow bQ\left[1 + \frac{1}{B}\right] - \frac{n(c_s - c_l)}{B} = a - c_s$$

Therefore

$$Q = \frac{1}{b} * \left(\frac{B(a - c_s) + n(c_s - c_l)}{B + 1}\right)$$

We plug Q in previous equations to compute price:

$$P = \frac{a + Bc_s - n(c_s - c_l)}{B + 1}$$

The individual inputs of a large q_l and small firm q_s:

$$q_l = \frac{1}{b}\left[\frac{a - c_l + m(c_s - c_l)}{B + 1}\right] \; ; \; q_s = \frac{1}{b}\left[\frac{a - c_s - n(c_s - c_l)}{B + 1}\right] \qquad (6) \; \& \; (7)$$

And the Herfindahl-Hirschman index of the industry $HHI = 10.000\left[n(\frac{q_l}{Q})^2 + m(\frac{q_s}{Q})^2\right]$

Using $\pi = P * q - C(q, k)$ we compute the individual profits:

$$\pi_l = \frac{1}{b}\left[\frac{a - c_l + m(c_s - c_l)}{B + 1}\right]^2 \; ; \; \pi_s = \frac{1}{b}\left[\frac{a - c_s - n(c_s - c_l)}{B + 1}\right]^2 \qquad (8) \; \& \; (9)$$

We observe that at equilibrium, profits are constantly positive.
After a merger, the number of firms diminishes to $B - 1$ which creates another equilibrium. Using equation (5) and following the same steps as before we have:

Scenario s1: symmetric merger between two small firms

From the global output of the industry:

$$Q^{s1} = \sum_{i=1}^{n+m-1} q_i^* = (n+1)q_l^* + (m-2)q_s^*$$

Following the same steps as before, we obtain:

$$Q^{s1} = \frac{1}{b} * \left(\frac{(B-1)(a-c_s) + (n+1)(c_s - c_l)}{B}\right)$$

$$P^{s1} = \frac{a + (B-1)c_s - (n+1)(c_s - c_l)}{B}$$

$$q_l^{s1} = \frac{1}{b}\left[\frac{a - c_s + (m-1)(c_s - c_l)}{B}\right] \ ; \ q_s^{s1} = \frac{1}{b}\left[\frac{a - c_s - (n+1)(c_s - c_l)}{B}\right]$$

$$\pi_l^{s1} = \frac{1}{b}\left[\frac{a - c_s + (m-1)(c_s - c_l)}{B}\right]^2 \ ; \ \pi_s^{s1} = \frac{1}{b}\left[\frac{a - c_s - (n+1)(c_s - c_l)}{B}\right]^2$$

Scenario s2: asymmetric merger between a large firm and a small firm

With

$$Q^{s2} = \sum_{i=1}^{n+m-1} q_i^* = nq_l^* + (m-1)q_s^*$$

We get

$$Q^{s2} = \frac{1}{b} * \left(\frac{(B-1)(a-c_s) + n(c_s - c_l)}{B}\right)$$

$$P^{s2} = \frac{a + (B-1)c_s - n(c_s - c_l)}{B}$$

$$q_l^{s2} = \frac{1}{b}\left[\frac{a - c_s + m(c_s - c_l)}{B}\right] \ ; \ q_s^{s2} = \frac{1}{b}\left[\frac{a - c_s - n(c_s - c_l)}{B}\right]$$

$$\pi_l^{s2} = \frac{1}{b}\left[\frac{a - c_s + m(c_s - c_l)}{B}\right]^2 \ ; \ \pi_s^{s2} = \frac{1}{b}\left[\frac{a - c_s - n(c_s - c_l)}{B}\right]^2$$

4.1.3.3. Merger valuation

As previously established in equation (2), the NPV value of the merger of firm i and firm j:

$$NVP = V_m - V_i - V_j - C_m$$

Depends on the standalone value of firms in a pre-merger state $V_i^\tau = \sum_0^\infty \frac{\pi_i}{(1+r)^i}$ and the expected value of the merged entity $V_m^\tau = \sum_0^\infty \frac{\pi_m}{(1+r)^i}$. We assume that all firms are subject to the same discount rate. Although, it may slightly differs in real life.

For notational simplification, we will drop the $\mathrm{E}^\tau[.]$ since the value is the summation of discounted expected values of profit as perceive in at time τ.

Scenario s1: symmetric merger between two small firms

In this case, we write the NPV as follows:

$$NVP^{s1} = V_m^l - 2V_s - C_m^s$$

$$\rightarrow NVP^{s1} = \sum_0^\infty \frac{\frac{1}{b}\left[\frac{a-c_S+(m-1)(c_S-c_l)}{B}\right]^2}{(1+r)^i} - 2 * \sum_0^\infty \frac{\frac{1}{b}\left[\frac{a-c_S-n(c_S-c_l)}{B+1}\right]^2}{(1+r)^i} - C_m^s$$

Scenario s2: asymmetric merger between a large firm and a small firm

In this case, we write the NPV as follows

$$NVP^{s2} = V_m^l - V_l - V_s - C_m^l$$

$$\rightarrow NVP^{s2} = \sum_0^\infty \frac{\frac{1}{b}\left[\frac{a-c_S+m(c_S-c_l)}{B}\right]^2}{(1+r)^i} - \sum_0^\infty \frac{\frac{1}{b}\left[\frac{a-c_l+m(c_S-c_l)}{B+1}\right]^2}{(1+r)^i} - \sum_0^\infty \frac{\frac{1}{b}\left[\frac{a-c_S-n(c_S-c_l)}{B+1}\right]^2}{(1+r)^i} - C_m^l$$

We will not develop these equations further and leave them to be computed by the algorithm at each iteration.

At this stage, we were able to formulate the price, the outputs and the NPV as functions of the industry demand price (a), price elasticity (b), marginal costs $(c_s; c_l)$, the number of active firms (B), and the WACC (r). In the following section and in order to proceed with modelling, we shall estimate these values in real market conditions.

4.1.3.4. Inverse Demand Function

(Hackbarth and Miao 2012) assume that the industry demand shock is a geometric Brownian motion process $\partial a(t) = \mu a(t)\partial t + \sigma a(t)\partial W(t)$ with μ and σ constants and $W(t)_{t\geq 0}$ the increment of a standard Brownian motion[1]. Therefore, we can rewrite the equation above as follows[2]

$$\frac{\partial a(t)}{a(t)} = \mu * \partial t + \sigma * \partial W(t) \rightarrow \Delta a_{yearly} = \mathcal{N}(\mu, \sigma^2)$$

Since demand prices mirror the demand fluctuation, we will use the latter as a proxy to capture this fluctuation (the mean and the variance). Using the annual demand growth for container

[1] $W(t)_{t\geq 0}$ is normally distributed with mean = 0, variance β ≥ 0 and a probability density function $f_t(x) = \frac{1}{\sqrt{2\pi t}} e^{-\frac{x^2}{2t}}, x \in \mathbb{R}, t > 0$

[2] The correct mathematical expression is $\Delta a = \mu\Delta t + \sigma * \varepsilon\sqrt{\Delta t}$ (Marathe and Ryan 2005), with $\Delta t = 1\ year$

shipping starting 1996 from Clarkson database[1] we obtain $\mu = 0.0699$ and $\sigma = 0.051$. (Marathe and Ryan 2005) established that for a Geometric Brownian motion $a(t)$ we have:

$$E[a(t)] = a_0 e^{\left(\mu + \frac{\sigma^2}{2}\right)t}$$

It follows that to simulate expected values of the demand price, we only need the initial value. Using the inverse demand function (equation 4), we apply a regression analysis on Maersk prices and the total market demand starting 2008, to estimate the coefficients of the inverse demand function. We obtain that $a_{average} = \$4725$ $(p - value = 0.003472)$ and $b = 1.35121.10^{-5}$ $(p - value = 0.0958)$. Although, the model fits poorly $(R^2 = 34.58\%, p - value = 0.0958)$, the assumptions[2] have been validated with acceptable p-values. Plugging price and total demand of 2008, we obtain $a_0 = \$3466$.

In this model adjustment, we tie marginal costs to demand price since they are all linked in real life. Demand, for instance, is associated with GDP growth which is relatively influenced by energy prices. The latter constitute the major part of shipping companies' marginal cost. The parameter settings will be disclosed in the simulation section.

4.1.3.5. Merger probability

Based on the merger valuation, we will assess the probability to merge for a firm given the geometric Brownian process a which captures the most the industry shock. (Hackbarth and Miao 2012) assimilate the decision to merge to a European call option, a firm decide to exercise at a "*value-maximizing*" time. We assume to have similar settings as a self-financing[3] portfolio with no dividend. Unlike (Hackbarth and Miao 2012), our aim is to assess the transition probabilities between states. For that, we only need to estimate the probability that a call option will be exercised regardless of the value of the option[4]. To do so we will use the Black–Scholes formula[5]:

$$O(S(t), t) = S(t) * \mathcal{N}(d_1) - e^{-r(T-t)} * K * \mathcal{N}(d_2)$$

with

$$d_1 = \frac{\ln\frac{S(t)}{K} + \left(\mu + \frac{\sigma^2}{2}\right) * (T - t)}{\sigma\sqrt{T - t}}, d_2 = d_1 - \sigma\sqrt{T - t}$$

The option value $O(S(t), t)$ in our case is the merger surplus. The function $S(t)$ is the value V_m of the merged company. The K stands for the stand-alone value of the firm pre-merger added to the cost to merge. Since we want a probability to merge in one iteration, time to maturity $T - t$ will be set to one year over the total number of years in the NPV horizon.

Our interest for the transition probabilities will be on the term $\mathcal{N}(d_2)$, since it represents the probability that a call option will be exercised (Nielsen 1992). To do so, we need to assume that V_m is lognormally distributed. That is:

$$\ln(V_m) = \mathcal{N}\left(\left(\mu - \frac{\sigma^2}{2}\right)(T - t), \sigma^2(T - t)\right)$$

A requirement never met in real life, even for stock option prices. One of the major critics to Black Scholes formula. Therefore, considering the structure of formulas we have in Section "Merger valuation", we will not dwell on demonstrating lognormality. We chose instead, to test the

[1] See annex C

[2] Normality, collinearity and heteroscedasticity

[3] A portfolio is self-financing if it involves no injection nor extraction of cash at any time.

[4] The optimization phase will be let to the MDP to assess the best policy that maximizes the call option value.

[5] (Hackbarth and Miao 2012), like several literature, provide a probability of a merger to occur based on this formula.

efficiency of $\mathcal{N}(d_2)$ in predicting mergers even if this assumption does not hold. The technic and assumptions imagined by (Hackbarth and Miao 2012) to avoid this issue are not straight forward to use in our case.

4.1.3.6. Default probability

At first, we considered using the Altman Z score of shipping companies. The Z-score is a reliable tool designed by (Altman 1968) that uses fiancial ratios to predict corporate failure. A firm with a score bellow 1.8 is belived to be in a financial distress zone.

Unfortunately, the score cannot be transformed accurately into a probability density. We opted then for a Poisson distribution given that 30 years separated between the last two large bankruptcies in the container shipping according to (Wright and Jung-a 2016). The probability density is then expressed as follows:

$$f(t) = \frac{\lambda^t e^{-\lambda}}{t!} \; with \; \lambda = \frac{1}{30 \; years}$$

4.2. Simulation and Findings

4.2.1. Deterministic simulation

Now that a deterministic value function has been set, we will simulate market behaviour under the assumption of rational decision-makers with full visibility[1] of the market at $time = \tau$, but myopic beyond that scope. In such conditions as these, we solely evaluate the synergy potential of mergers excluding the possibility of bad management (identical firms) or Hubris motives[2].

In this section, we will apply (Hackbarth and Miao 2012) condition of fixed and non-depreciating capital. Therefore, no entry nor exit market will be simulated.

To mimic container shipping market and to prevent the equilibrium at each iteration to be distorted, we establish the following rules:

- There are two scenarios for mergers:
    - Scenario one: a symmetric merger between two small firms. The number of small firms will decrement by two while the number of large firms will increase by one.
    - Scenario two: an asymmetric merger between a small and a large firm (a takeover). The number of small firms will decrease by one, and the number of large firms will remain unchanged.
- One merger operation per iteration: since we have 2-type players, at the initialisation phase and if the conditions of merger are met, all of them will want to engage in a merger simultaneously. Therefore, we set this condition to prevent such behaviour and to preserve the equilibrium stability.
- If more than one merger can take place—in case of multi-bidders with one large firm and one small firm bidding at the same over a third small firm—there can be two possibilities. Either the large bidder will win the bid over the small one since the large firm can afford to offer a larger premium as (Hackbarth and Miao 2012) have advocated. We may also consider the other scenario where the merger with the highest NPV should take place. We will proceed with the latter, and later, we will check the other possibility.
- If the number of small firms is less than 2, and even if merger conditions are met, scenario two cannot take place. Similarly, if the numbers of small firms and large firms are both less than one, scenario one cannot take place.

[1] Full visibility at the current year. The agents have no information about the future upon deciding on merger.
[2] In this section the algorithm is designed to simulate only mergers with positive surplus.

- Equation (5) implies that in order to have positive values for outputs, we must ensure that $P \geq d$ which means $a - c_s - n(c_s - c_l) \geq 0$ in equation (7)[1], given that n is increasing in each iteration. For that we set costs as follows[2]:

$$c_s = \alpha * a + \mathcal{N}(0, 10^2)$$
$$c_l = \beta * c_s + \mathcal{N}(0, 10^2)$$
$$with\ 0 < \alpha \leq 1\ and\ 1 - \frac{\alpha - 1}{n} \geq \beta \geq 1 + \frac{1}{n} - \frac{1}{\alpha * n}$$

For α and β we generate two vectors of random variables with uniform distributions $\mathcal{U}(0.65{,}0.9999)$ [3]and $\mathcal{U}(\frac{101\alpha-1}{100\alpha}, 0.9999)$. With these victors, we ensure to have different variables for each iteration. The normal distribution is added to generate noise.

- For the price elasticity, we use the result of the regression analysis conducted on the inverse demand function: $b = 1.35121.10^{-5}$
- The industry demand price is modelled by a geometric Brownian motion using the result of the descriptive statistical analysis of the inverse demand function: $a = \mathcal{B}(\mu = 3.956\%$, $\sigma = 6\%)$. These values will be altered in the future to simulate recession and economic boom.
- The discount rate is also randomly generated in each iteration using a uniform distribution $\mathcal{U}(0.08{,}0.14)$ same range of values used by CMA CGM to assess NOL merger[4].
- The NPV value is computed for ten years assuming no growth[5], taking the profits of the current year of iteration as a reference. It is worth mentioning that (Hackbarth and Miao 2012) required $2\left(\mu + \frac{\sigma^2}{2}\right) < interest\ rate$ in order for the net present value to converge. This setting does not hold in our context with the new adjustment nor is it always true in shipping context.

The simulation allows for the user to use a specific value for all these random variables, in the case we are interested in testing a specific parameter impact on M&As. (Figure 8) depicts one possible outcome of a deterministic simulation with a starting market structure of $n = 3$ oligopolies and $m = 17$ small firms in a period of ten years. Costs to merge are set to zero, prices and marginal costs are expressed by US dollars and the output is the annual FFE slot sold.

---

[1] If equation (7) is positive, equation (6) is also positive. Therefore, we only check equation (7)

[2] Assuming that we will not simulate more than one hundred oligopolies and keeping in mind that $c_s \geq c_l$ as previously discussed.

[3] We assume that marginal costs in container shipping cannot be lower than 65% of the market demand price.

[4] CMA CGM annual report 2016

[5] Same prudent assumption used by CMA CGM to assess NOL merger.

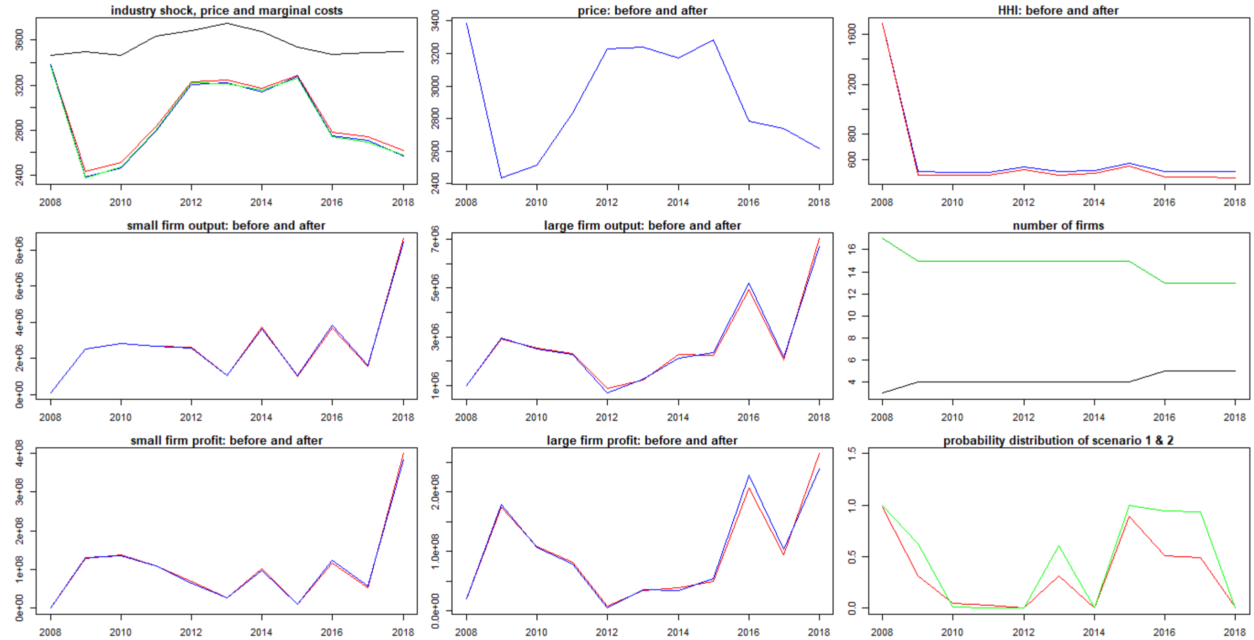


Figure 8: deterministic simulation of M&As. The blue line is initial market without M&As taking place and the red line is market with M&As. For a detailed legend see annexe D

After a series of simulations, we notice that mergers take place only when production costs are significantly high or if demand endures a shock[1] as shown in (Figure 8) in years $\epsilon\{2008; 2015\}$. Prices bear little to no change as a result of consolidation. Indeed, they go slightly higher during the year of merger, as suggested by many literature, but they rapidly regain their original course. Also, firms' profit declines in the long run especially when a series of mergers take place. The HHI index, although features spikes at the years the mergers took place, tends to correct itself afterwards.

To establish the impact of merger costs in the decision to merge and using (Hayward and Hambrick 1997) estimates, we generate a random premium $\mathcal{N}(49\%; 39\%^2)$ as percentage of the target firm. We find that the dominance of the industry cycle makes it hard to assess or to infer any impact. Although, under general impression, when the market concentration is higher than the previous setting (e.g. $n = 3\ and\ m = 5$) and with obvious favourable market conditions, the occurrence of mergers is lower. (Figure 9) shows that no M&A activity took place, while in (Figure 8), the first merger took place early 2008. We observe that in the year of merger, the costs were significantly higher compared to demand price in both simulations.
After several simulations, no notable trend was noticeable. Therefore, we abstain from concluding on a causality effect of merger costs.

[1] Substantial variation, also called a jump.

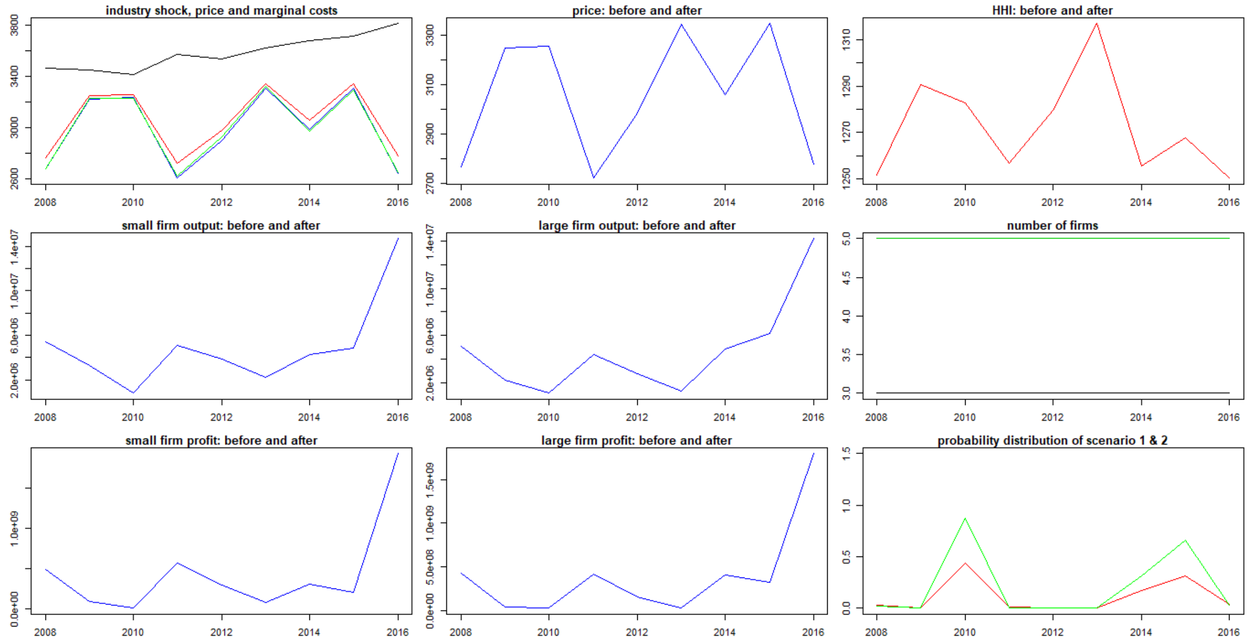


Figure 9: deterministic simulation with costs to merge included. Initial market structure: n=3 oligopolies and m=5 small firms

From equations (7) and (8) we concluded that at Cournot-Nash equilibrium with stable market conditions, the profits are always positive. In real life, such configuration is simply not realistic. Liners suffered substantial losses during the scope of research. Therefore, a deterministic simulation of mergers at stable market equilibrium may serve as a reference but does not provide a life-like market behaviour during instability periods. To accommodate our simulation for possible negative values for profit, we relax the previous condition $a - c_s - n(c_s - c_l) \geq 0$ and extend the range of costs so that we may have either $c_l \leq P \leq c_s$ or $P \leq c_l \leq c_s$.
The new settings for α and β is $\mathcal{U}(0.65,1.09)$ [1] and $\mathcal{U}(0.85,1)$ respectively.

Following the exact steps as before and in order to preserve positive values for outputs, we update equations (6) and (7) as follows:

$$q_l' = \max\left(0, \frac{1}{b}\left[\frac{a - c_l + m(c_s - c_l)}{B + 1}\right]\right) \; ; \; q_s' = max\left(0, \frac{1}{b}\left[\frac{a - c_s - n(c_s - c_l)}{B + 1}\right]\right)$$

Afterward, we revise the values of the total output, prices and profits according to the settings of the new pseudo-equilibrium $Q' = q_l' + q_s'$; $P' = a - b * Q'$; $\pi' = (P' - d) * q'$
The firm valuation based on possible negative cash flows, needs to be revised accordingly. A firm acquiring a non-profitable firm is buying its liabilities, and therefore we will update the NPV as follows:

$$NPV = V_m - |V_i| - |V_j|$$

Notice that we set the cost of merger in case of negative NPV, to zero since a bankrupted firm cannot ask for a premium beside the salvage price of its debt. The similar concern arises when computing the probability distribution since we should fit the values for the logarithm function. We proceed by the same approach.

[1] Allowing costs to be 9% higher than the demand price.

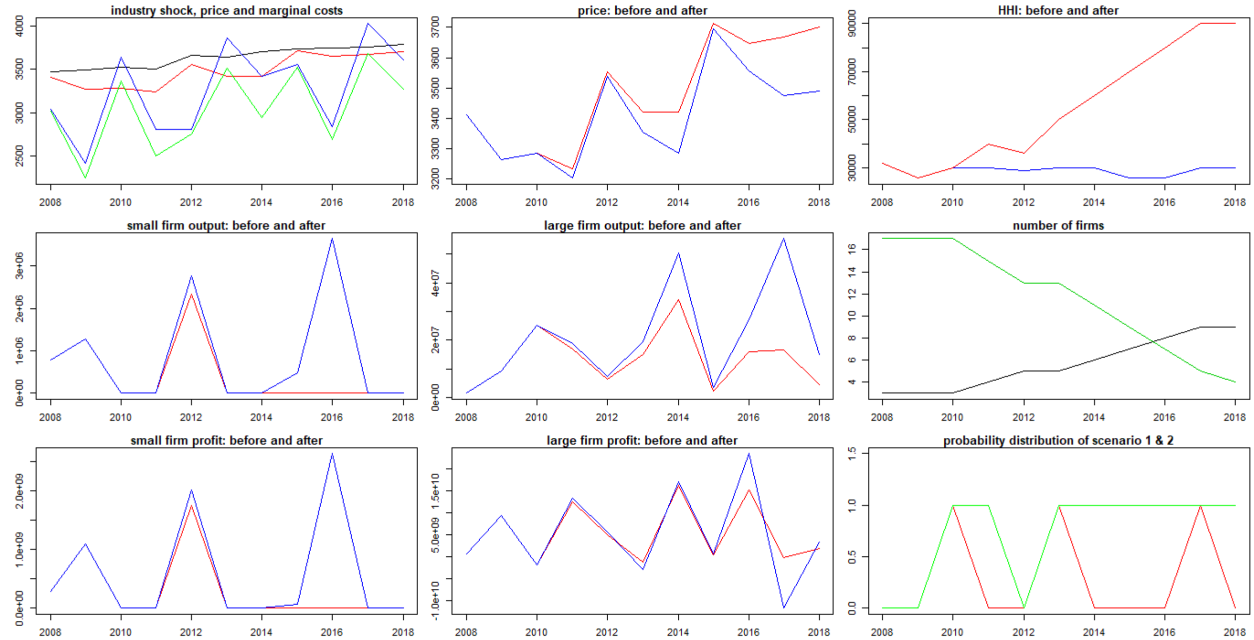


Figure 10: deterministic simulation of M&As with sporadic high marginal costs. Premium included in merger valuation. Initial market structure: n=3 oligopoly and m=17 small firms

The difference in the outcome is quite staggering. During market instability, M&As are more frequent and cause prices to rise due to a decreased output level. The important point here is that outputs are reduced not because of limited capacities[1] but rather because of small firms' unproductivity $c_s > c_l$ aggravated by sporadic low freight rates that do not cover the costs. As a result, small firms are either forced out of the market[2] or to become competitive through mergers to realise economies of scale. The profits erode drastically with the occurrence of mergers. The HHI index signals constantly a high concentrated market compared to stable market simulations. For instance, (Figure 10) shows that at years $\in \{2010; 2013; 2017\}$, marginal costs (c_s is represented by the blue line, c_l by the green line) rose remarkably above market price (red line). As a result, oligopolies suffered negative profits in those years, while small firms stopped producing any output starting 2013. A situation similar to market exit. After several simulations, we notice the persistence of this trend. In bullish market conditions, oligopolies suffer negative profits while small firms are forced to either merge or cease activity. Never oligopolies shut down since they produce at the lowest cost.
The probability distribution based on the Black Scholes formula, successfully predicts mergers if the number of eligible firms allows it[3]. Moreover, many simulations were conducted, and their Q-Q plots depict similar features as shown in (Figure 11). Therefore, we can state that the assumption of log-normality over time roughly holds in our stochastic process.

---

[1] As previously discussed the research scope starting 2008 is characterized by overcapacity in container shipping and therefore our model, in the form of the cost function, illustrates an incapacitated model.
[2] In the graphs, we observe long periods of inactivity $q = 0$
[3] In some cases, the distribution function shows a high probability for a merger to happen while no merger occurs since we have restrictions on the number of firms. It is an intuitive result: even if merger conditions are met, there can be no merger if no eligible firm is left to merge with.

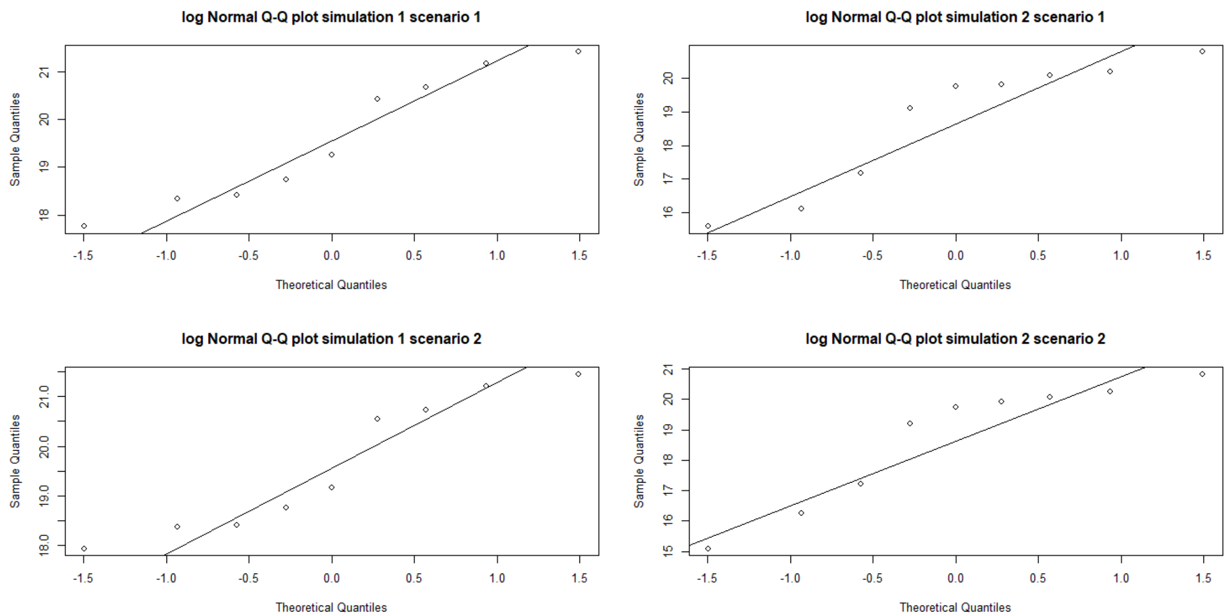


Figure 11: The Q-Q plot of log(V_m) of both merger scenarios in two different simulations

Another observation is that when both merger scenarios can take place—both with high probabilities—and since only the one with the highest NPV can take place as restricted in the algorithm, scenario 1 prevails compared to scenario 2 in most simulations. Especially when the spread between marginal costs is large. A finding that suggests that the potential synergy in a symmetric merger is higher[1] than with an asymmetric merger. However, like (Hackbarth and Miao 2012) suggested, in real life, large bidders always win the takeover since the target shareholders look for the immediate profit in the form of a large premium with cash that only the large bidder can afford.

To test the efficiency of the probability distribution function to predict scenario 2, we change the merger law in the algorithm: if two mergers can take place, the merger with the largest bidder should take place.

We observe in (Figure 12) that the probability distribution of scenario 2 (the red line) hits the value one in years $\in \{2014; 2017; 2018\}$, while the number of firms confirms that a merger according to scenario 2 has indeed taken place in those years even if the probability distribution of scenario 1 (the green line) is also one in those years. Compared to (Figure 10) when scenario 1 prevails in years $\in \{2010; 2013\}$ even though the two distributions reach both high probabilities values. Although, scenario 2 occurs in the year 2017 signalling that they may be circumstances for an asymmetric synergy to be more profitable. When both distributions have low figures, no merger takes place in the corresponding year.

[1] The two small firms instead of producing with the highest marginal cost will prefer merge and produce with the lowest cost. In the asymmetric merger, the large firm already produces at low cost and the potential synergy is to be achieved only on the output of the small firm.

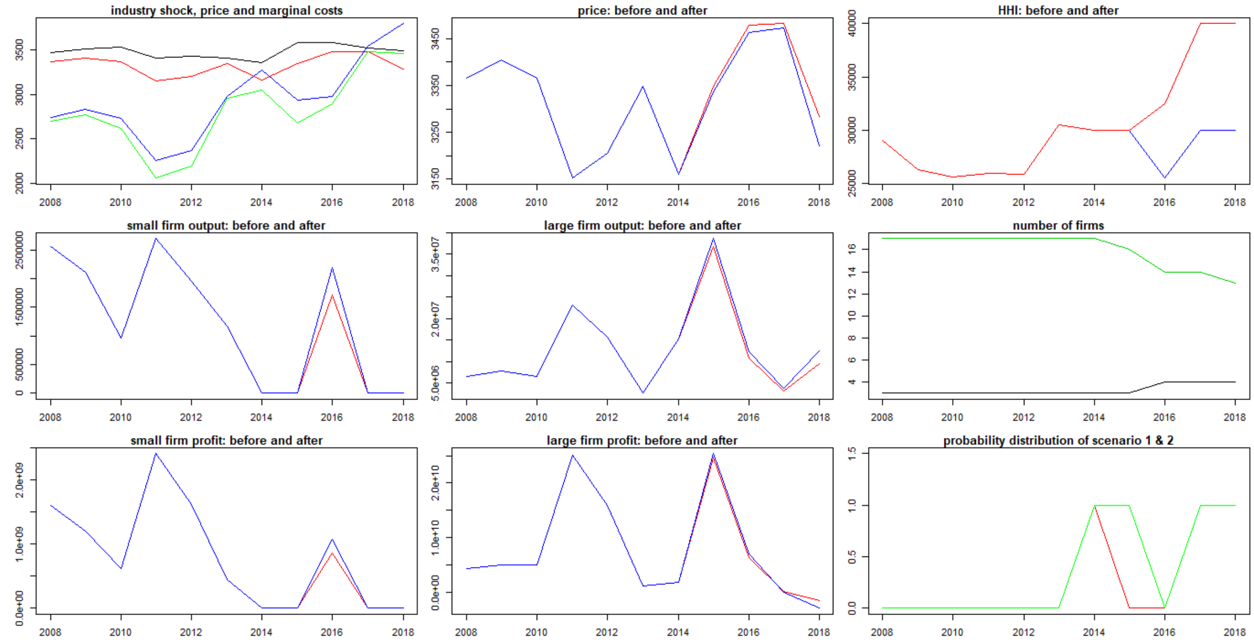


Figure 12: A deterministic simulation of M&As. Merger law: if two mergers can take place, only the one with the large bidder should take place. Initial market structure: n=3 oligopoly and m=17 small firms

We never came across a simulation where the distribution probability outcome did not match the merger scenario. Therefore, we conclude on the suitability of the Black Scholes formula to generate the transition probabilities for the next MDP simulation.

4.2.2. MDP simulation

With the reward function and the probability distribution of merger established, we are able to design the MDP for a probabilistic simulation. We must keep in mind as (Powell 2011) have explained, that a deterministic simulation merely provides a sequence of possible actions while the MDP provides for the best decision to perform among these actions given the process's initial state and the probability transition.

In the following, we will lose the constraint on the fixed capital amount in the simulation. Our model with horizontal marginal costs allows for us to simulate market exit unlike (Hackbarth and Miao 2012) who were dependant on the amount of capital to build the cost function. However, we will not include the premium in the merger valuation to avoid a cumbersome model. We were able to notice a limited effect on merger occurrence during deterministic simulations, therefore its omission cannot have a substantial impact on the model.

Synergy in equation (2) will then be assessed by:

$$NVP = V_m - V_i - V_j$$

We revisit the previous definition of the model $MDP = \langle \mathrm{S, A, P, R, \gamma} \rangle$ stated in the methodology section:

- The finite state space:
  $S = \{small\ firm\ ; large\ firm; merger; bankrupted\ firm\} \equiv \{s_1; s_2; s_3; s_4\}$;
- The action space $A = \{merge; acquire\ ; stay - put\ \} \equiv \{a_1; a_2; a_3\}$;

The action "merge" is equivalent to scenario 1 in the previous deterministic simulation, while action "acquire" is equivalent to scenario 2.

- The transition probabilities $P^{a}_{ss'}$, for each action a_i:

$$\begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix} \text{ such that } \forall i \sum_{j} p_{ij} = 1$$

Since the space action A contains three actions, it follows that the probability transition matrix of the MDP is as follows:

$$P^{a_1}_{ss'} = \begin{bmatrix} p_{11} & p_{12} & p_{13} & p_{14} \\ p_{21} & p_{22} & p_{23} & p_{24} \\ p_{31} & p_{32} & p_{33} & p_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}; P^{a_2}_{ss'} = \begin{bmatrix} p'_{11} & p'_{12} & p'_{13} & p'_{14} \\ p'_{21} & p'_{22} & p'_{23} & p'_{24} \\ p'_{31} & p'_{32} & p'_{33} & p'_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}; P^{a_3}_{ss'} = \begin{bmatrix} p''_{11} & p''_{12} & p''_{13} & p''_{14} \\ p''_{21} & p''_{22} & p''_{23} & p''_{24} \\ p''_{31} & p''_{32} & p''_{33} & p''_{34} \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

To build the transition probabilities $P^{a}_{ss'}$, we establish the following settings:

- A firm can only reach the state s_4 ("bankrupted") through a "stay-put" strategy (a_3), the probability to leave that state is null. s_4 is called an absorbing state. It follows that:

$$\begin{cases} p_{14} = p_{24} = p_{34} = 0 \\ p'_{14} = p'_{24} = p'_{34} = 0 \end{cases}$$

- When a firm reaches s_2 ("large firm"), the probability to go to s_1 ("small firm") is null[1]. Therefore $p_{21} = p'_{21} = p''_{21} = 0$
- A firm in state s_1 ("small firm") cannot go to state s_2 ("large firm") directly without merger, therefore the probability is null[2]: $p_{12} = p'_{12} = p''_{12} = 0$
- When a firm reaches s_3 ("merger"), it becomes a large firm, therefore the probability to go to s_1 ("small firm") is null. We also assume that no merger should go bankrupt during the year of the merger[3]. Moreover, a firm in the state s_3 cannot engage in another merger until it leaves that state[4]. A firm can only leave state s_3 to state s_2 when it engages into a "stay-put" strategy (a_3). It follows:

$$\begin{cases} p_{33} = 1\,;\ p_{31} = p_{32} = p_{34} = 0 \\ p'_{33} = 1\,;\ p'_{31} = p'_{32} = p'_{34} = 0 \\ p''_{32} = 1\,;\ p''_{31} = p''_{33} = p''_{34} = 0 \end{cases}$$

s_3 is a transitory state created to distinguish rewards when a large firm engages in a "stay-put" strategy compared to "acquire" strategy since both actions lead to the same state. s_3 is called a reflecting barrier.

- A firm in state s_2 cannot engage into merger through action a_1 it follows:

$$\begin{cases} p_{22} = 1 \\ p_{23} = 0 \end{cases}$$

- When a firm engages in a "stay-put" strategy (a_3), it cannot reach s_3 the "merger" state. Therefore: $p''_{13} = p''_{23} = 0$
- A large firm and a small firm engage in action a_2 simultaneously $p'_{13} = p'_{23}$
- Since we are using the same Poisson distribution for bankruptcies' occurrence for all firms' types we have: $p''_{14} = p''_{24}$

---

[1] This research does not assume firms to downsize their capital.

[2] This research does not address the scenario of internal growth. Therefore, in our settings, a small firm can grow to become a large firm only through merger.

[3] To conduct a merger, firms are assisted by third parties (financial and legal advisors), hence no substantial bankruptcy risk if the merger is approved by the shareholders.

[4] If a firm engages in merger at t=i it cannot engage into merger at t=i+1. To mimic realistic market conditions where it takes longer than one year to complete a merger

Subsequently, the transition matrix is simplified as follows:

$$P_{ss'}^{a_1} = \begin{bmatrix} p_{11} & 0 & p_{13} & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}; P_{ss'}^{a_2} = \begin{bmatrix} p'_{11} & 0 & p'_{13} & 0 \\ 0 & p'_{22} & p'_{13} & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}; P_{ss'}^{a_3} = \begin{bmatrix} p''_{11} & 0 & 0 & p''_{14} \\ 0 & p''_{22} & 0 & p''_{14} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Such that

$$\begin{cases} p_{11} + p_{13} = 1 \\ p'_{11} + p'_{13} = 1 \\ p'_{22} + p'_{13} = 1 \\ p''_{11} + p''_{14} = 1 \\ p''_{22} + p''_{14} = 1 \end{cases}$$

Previously, we established the probability distribution of merger according to scenario 1 (equivalent to action a_1) and scenario 2 (equivalent to action a_2). Therefore, p_{13} and p'_{13} are known. We also established the probability of default, so p''_{14} is also known. We consolidate all the above and reconstruct the MDP transition probabilities as follows:

$$P_{ss'}^{a_1} = \begin{bmatrix} 1-p_{13} & 0 & p_{13} & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}; P_{ss'}^{a_2} = \begin{bmatrix} 1-p'_{13} & 0 & p'_{13} & 0 \\ 0 & 1-p'_{13} & p'_{13} & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}; P_{ss'}^{a_3} = \begin{bmatrix} 1-p''_{14} & 0 & 0 & p''_{14} \\ 0 & 1-p''_{14} & 0 & p''_{14} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- The reward matrix R_s^a in accordance with the transition matrix, has the following general form:

$$R_s^{a_1} = \begin{bmatrix} r_{11} & 0 & r_{13} & 0 \\ 0 & r_{22} & 0 & 0 \\ 0 & 0 & r_{33} & 0 \\ 0 & 0 & 0 & r_{44} \end{bmatrix}; R_s^{a_2} = \begin{bmatrix} r'_{11} & 0 & r'_{13} & 0 \\ 0 & r'_{22} & r'_{23} & 0 \\ 0 & 0 & r'_{33} & 0 \\ 0 & 0 & 0 & r'_{44} \end{bmatrix}; R_s^{a_3} = \begin{bmatrix} r''_{11} & 0 & 0 & r''_{14} \\ 0 & r''_{22} & 0 & r''_{24} \\ 0 & r''_{32} & 0 & 0 \\ 0 & 0 & 0 & r''_{44} \end{bmatrix}$$

As previously established in the methodology section, the objective of each firm is to maximise its NPV, the economic value of the MDP model. Therefore, the reward matrix has to reflect the annual profits. Assets and liabilities are not included. To design for such configuration in the MDP model, we will establish the following settings:

- In state s_4 ("bankrupted firm"), a firm does not generate profits nor incur losses. It simply ceases activity. Therefore: $r''_{14} = r''_{24} = r''_{44} = 0$ this configuration allows the MDP to keep in memory the value of the firm just before bankruptcy in spite of further iterations.
- If a firm engages in "stay-put" action (a_3) it will perceive the stand-alone annual profit. The post-merger firm will exit the transitory state and regain the state "large firm". It follows:

$$\begin{cases} r''_{11} = \pi_s \\ r''_{22} = r''_{32} = \pi_l \end{cases}$$

- If a firm successfully achieves merger, it will perceive its share of the new entity's profit. If two small firms merge, they each will own half the capital of the new entity, and therefore the reward should be split in half. In case of a takeover, and proportionally to their capital ownership[1], the large firm will perceive $2/3$ of the new entity's profit and the small firm will cash in the remaining. From above, we establish:

[1] In "The scenarios" section we established the capital structure of the market $k_{Large} = 2 * k_{Small}$

$$\begin{cases} r_{13} = \frac{1}{2}\pi_m^{s1} \\ r'_{13} = \frac{1}{3}\pi_m^{s2} \\ r'_{23} = \frac{2}{3}\pi_m^{s2} \end{cases}$$

- If the firm fails to achieve the merger, there should be a penalty to reflect the lost costs of the unsuccessful operation. We set these costs to equal the negative absolute value of the expected stand-alone profit:

$$\begin{cases} r_{11} = -|\pi_s| \\ r'_{11} = -|\pi_s| \\ r'_{22} = -|\pi_l| \end{cases}$$

This penalty will prevent the MDP, while optimising, to go through mergers just to avoid negative profits in a stand-alone configuration. If there is no cost to failure, the MDP will always choose to merge.

- A firm in state s_2 ("large firm") cannot engage in action a_1. Therefore, to forbid the MDP to choose this action while in s_2 we must set a high penalty: $r_{22} = -\infty$
- A firm in state s_3 ("merger") cannot engage in either a_1 or a_2. Therefore:

$$r_{33} = r'_{33} = -\infty$$

- A firm in state s_4 ("bankrupted firm") cannot engage in either a_1 or a_2. Therefore:

$$r'_{44} = r_{44} = -\infty$$

We consolidate all the above and reconstruct the MDP reward matrix as follows:

$$R_s^{a_1} = \begin{bmatrix} -|\pi_s| & 0 & \frac{1}{2}\pi_m^{s1} & 0 \\ 0 & -\infty & 0 & 0 \\ 0 & 0 & -\infty & 0 \\ 0 & 0 & 0 & -\infty \end{bmatrix}; R_s^{a_2} = \begin{bmatrix} -|\pi_s| & 0 & \frac{1}{3}\pi_m^{s2} & 0 \\ 0 & -|\pi_l| & \frac{2}{3}\pi_m^{s2} & 0 \\ 0 & 0 & -\infty & 0 \\ 0 & 0 & 0 & -\infty \end{bmatrix}; R_s^{a_3} = \begin{bmatrix} \pi_s & 0 & 0 & 0 \\ 0 & \pi_l & 0 & 0 \\ 0 & \pi_l & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

(Figure 13) provides an illustrative diagram of the MDP.

Now that the MDP is defined, we will proceed with an adequate algorithm to solve the optimisation problem in the form of the Bellman equation (1). (Gordon 1999) explains that when the MDP is small, all algorithms[1] provide the same result. In our case and after testing all three algorithms, this holds true. Therefore, we proceed with the most convenient one: Policy Iteration (Figure 14). The algorithm picks a policy at random, checks for optimality by observing and comparing the resulting behaviour of the system, chooses the policy that performs better and moves to the next iteration. The MDP tests all the policies to provide the one with the optimal outcome.

[1] Value iteration, policy iteration and linear programming (LP)

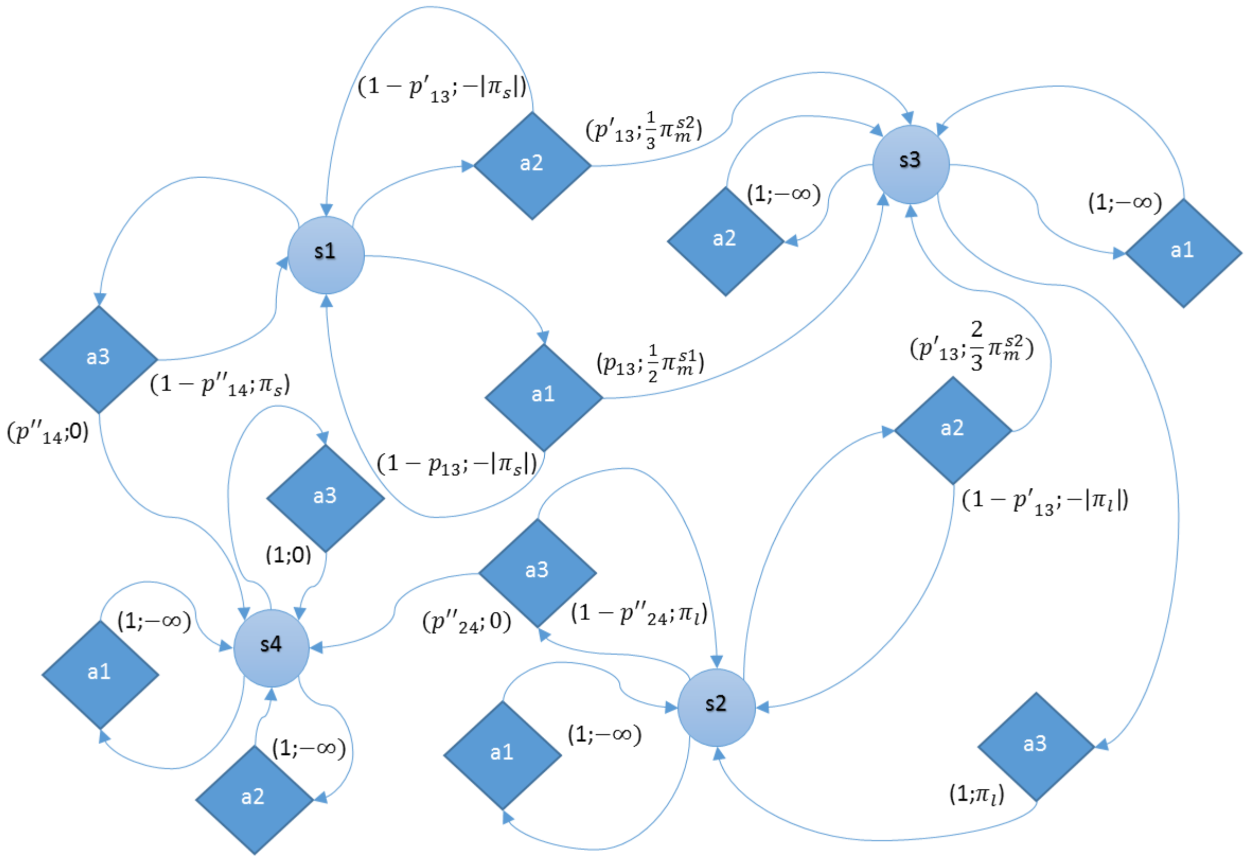


Figure 13: The transition probabilities and rewards (PxR) diagram of the MDP model.

1. Initialization
   $V(s) \in \Re$ and $\pi(s) \in \mathcal{A}(s)$ arbitrarily for all $s \in \mathcal{S}$

2. Policy Evaluation
   Repeat
   $\Delta \leftarrow 0$
   For each $s \in \mathcal{S}$:
   $v \leftarrow V(s)$
   $V(s) \leftarrow \sum_{s'} \mathcal{P}_{ss'}^{\pi(s)} \left[\mathcal{R}_{ss'}^{\pi(s)} + \gamma V(s')\right]$
   $\Delta \leftarrow \max(\Delta, |v - V(s)|)$
   until $\Delta < \theta$ (a small positive number)

3. Policy Improvement
   policy-stable $\leftarrow$ *true*
   For each $s \in \mathcal{S}$:
   $b \leftarrow \pi(s)$
   $\pi(s) \leftarrow \arg\max_a \sum_{s'} \mathcal{P}_{ss'}^{a} \left[\mathcal{R}_{ss'}^{a} + \gamma V(s')\right]$
   If $b \neq \pi(s)$, then *policy-stable* $\leftarrow$ *false*
   If *policy-stable*, then stop; else go to 2

Figure 14: iterative policy evaluation and policy improvement algorithm for finite state space in MDP.

We must be aware that the traditional definition of Markov Decision Process $MDP = \langle S, A, P, R, \gamma \rangle$ is time homogeneous. The probabilities, the rewards and the discount factor are considered

constant while the MDP optimizes the value function over time. However, the econometric model results are time variant values: a non-stationary process. Therefore, we must adapt the MDP to account for these variations. Some literature[1] deal with this issue by duplicating states over time to make the MDP homogeneous. It follows that the dimensions of the MDP will soon be unmanageable. In our model for instance, if we are to simulate a market in a period of twenty years, we will need 4^{20} states for each firm. The other possibility is to create a list of non-homogeneous Markov Chains.
We prefer to adapt the MDP algorithm instead by executing Policy Iteration Algorithm. We assume firms do not have future visibility and chose, at each iteration, an action that maximises their overall value taking the same horizon used in computing the NPV value in the deterministic simulation.

To preserve the equilibrium stability of the model, no more than one merger will take place (the large bidder wins) and in the year of a bankruptcy occurrence, no merger shall take place.
Since the case of a small firm bankruptcy is identical to scenario 2 in our model, we shall only model large bankruptcies. Therefore, we compute for the absorbing Markov Chain Process associated with each MDP, the expected time to absorption given the starting state $s_2$and to do so, the algorithm need to include several steps for each iteration:

- First, we define the absorbing Markov chain Process. From the 3-dimensions transition matrix, only $P_{ss'}^{a_3}$ is an absorbing matrix with an absorbing state at s_4. The other actions don't lead to bankruptcy.

$$P_{ss'}^{a_3} = \begin{bmatrix} 1-p''_{14} & 0 & 0 & p''_{14} \\ 0 & 1-p''_{14} & 0 & p''_{14} \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

- Second, we write the transition matrix of the absorbing Markov chain Process into its canonical form:

$$P_{ss'}^{a_3} = \begin{pmatrix} Q & R \\ 0 & I \end{pmatrix} with \begin{cases} Q = \begin{bmatrix} 1-p''_{14} & 0 & 0 \\ 0 & 1-p''_{14} & 0 \\ 0 & 1 & 0 \end{bmatrix} \\ R = \begin{bmatrix} p''_{14} \\ p''_{14} \\ 0 \end{bmatrix} \end{cases}$$

- Third, we compute the fundamental matrix of the absorbing Markov chain Process:

$$N = (I-Q)^{-1}$$

- Next, we compute the expected time (number of iterations) for the Markov Chain Process to be absorbed given a starting state:

$$\begin{bmatrix} t_1 \\ t_2 \\ t_3 \end{bmatrix} = N * \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$$

- Finally, using the expected time to absorption starting state s_2, we generate a random variable with a Poisson distribution[2] with $\lambda = \frac{1}{t_2}$.

[1] Such as medicine research and sport forecasts
[2] The mean value $t_2 \approx 31.01685\ iterations$ roughly 30 years of the initial default density

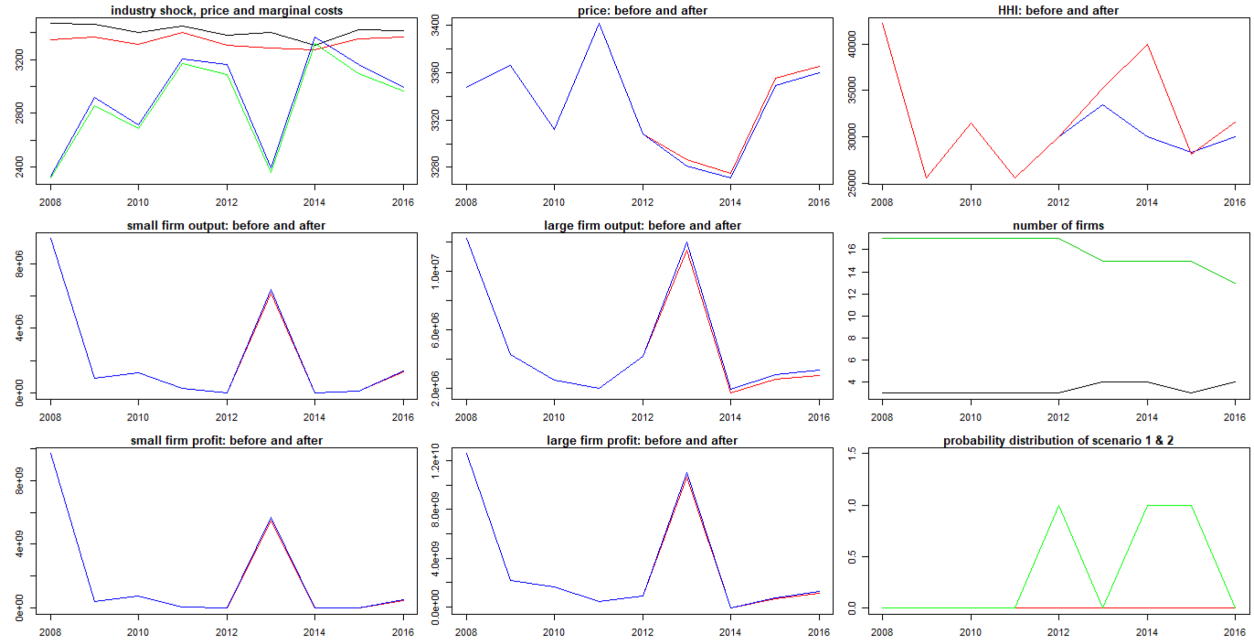


Figure 15: MDP simulation of M&As. Merger law: large bidder wins and no premium. Initial market structure: n=3 oligopolies and m=17 small firms

In (Figure 15), only one large bankruptcy took place at year = 2014. We observe that bankruptcies regulate prices back to the original market conditions before the merger. This result is intuitive since bankruptcies are the mean by which markets balance supply and demand. Since we only simulate large bankruptcies, the HHI declines as a result, showing a less concentrated market.

4.3. Result analysis and discussion

Since the problem statement is concerned with assessing the impact of operations' management on mergers and market exit, in the following sub-sections we shall configure for designated states of the world and observe how the MDP will react as a result. But first, we will challenge the optimality of the MDP policy given the partial visibility of the process.

4.3.1. Greedy policy vs optimal policy

Since our MDP uses a greedy algorithm due to the partial visibility of the market, the outcome is an approximate optimum policy. The random occurences of mergers and bankruptcies make it complex to design an algorithm with full visibility. To tackle this issue, we create a matrix history in the algorithm to store the NPV of each firm at each iteration. The objective is to compare the real NPV earned among firms which did merge and those which did not merge or did merge in a later iteration. If the greedy algorithm instructs a merger as the best policy at $t = \tau$ it should mean that firms who did not merge or merged after $t = \tau$ would realize a total NPV lower than that of the firms who did merge at the prescribed iteration.

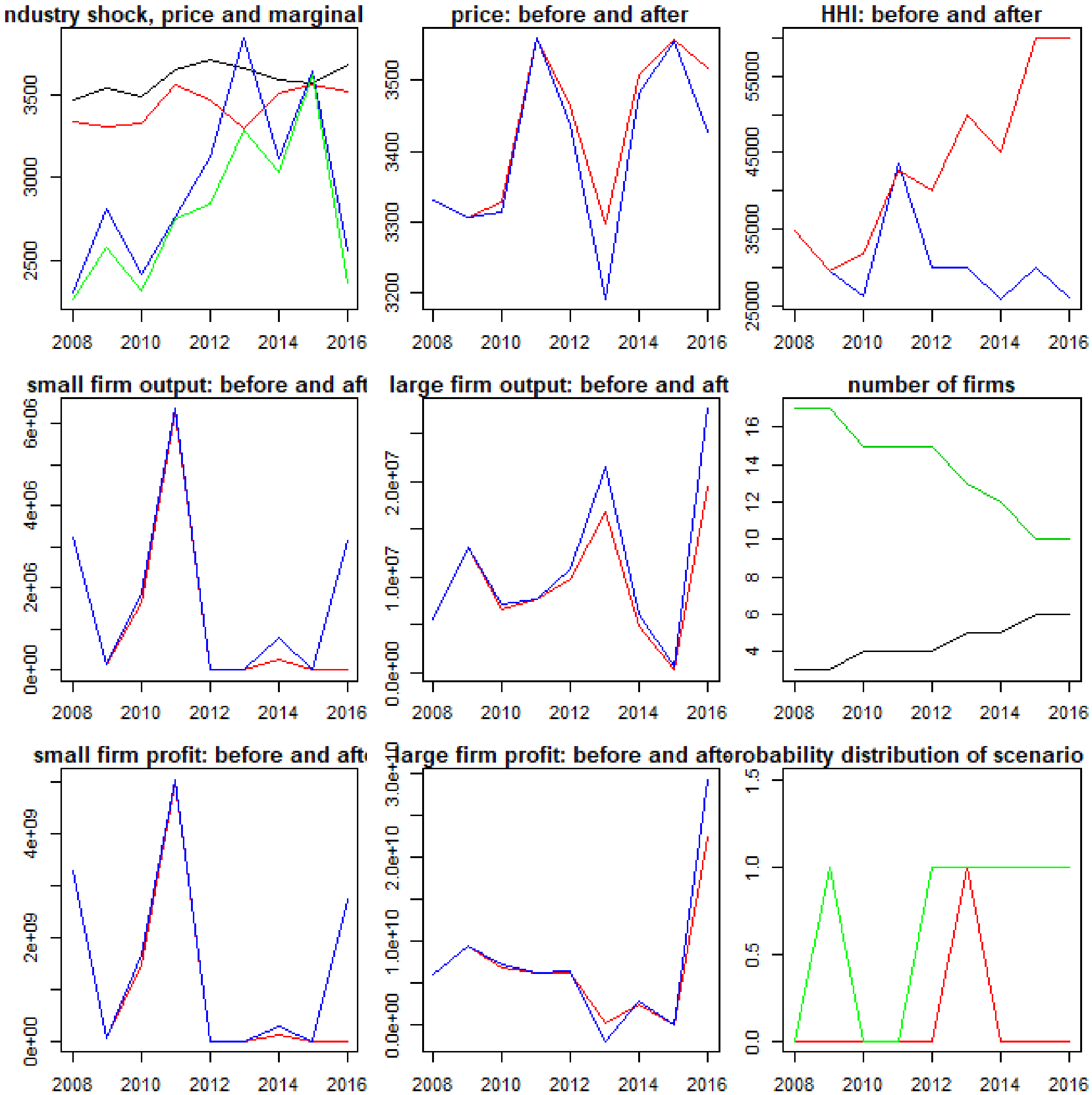


Figure 16: MDP simulation. Market structure n=3 oligopolies and m=17 small firms

In (Figure 16), four mergers occurred at the years $\in \{2009; 2012; 2013; 2014\}$ when the market experiences large variations in cost levels. Below a summary description of the firms' value at the end of the horizon.

Several simulations depict similar results as those shown in (Table 5). Although, the whole industry extracts more consumer surplus[1], only merged firms profit from the merger. The stay-put firms experience lower profits than expected. A finding that contradicts the conclusion of (Hackbarth and Miao 2012) where they discuss how rivals benefit from mergers' externalities (i.e. the free rider problem). We also notice that a delay in a merger has an opportunity cost. The algorithm's restriction of one merger per year, pushes firms to delay the decision and the cost of this delay is reflected in a lower realised NPV. This result goes against the free rider problem since it establishes no gain from merger delay but rather prove the "first mover" advantage. The

[1] Total market net surplus due to mergers, approximates \$25 billion in Table 5.

latter is supported by (Mason and Weeds 2010) who use a similar call option model to study irreversible investment under uncertainty. We find the first mover theory to provide a better explanation for why firms compete to merge when endogenous market factors are favourable for consolidation.

state	action	Year of action	Number of firms	Total realised NPV at 2016 (per firm[1])	Total expected NPV at 2008 (per firm)
Large firm	Stay put	2008 →2016	3	$59.345.576.963	$ 65.340.401.541
Small firm	Stay put	2008 →2016	10	$9.952.968.059	$ 13.120.965.568
Small firm	Merger	2009	2	$25.344.223.790	$ 13.120.965.568
Small firm	Merger	2012	2	$22.321.897.081	$ 13.120.965.568
Small firm	acquisition	2013	1	$18.078.609.949	$ 13.120.965.568
Small firm	Merger	2014	2	$21.141.559.220	$ 13.120.965.568
Total	-	-	-	$156.184.835.062	$130.945.229.381

Table 5: the actual NPV at the end of the MDP simulation horizon of Figure 16

We conclude that even though our MDP uses a greedy algorithm, the nature of the stochastic process makes the outcome not an approximate optimum but in fact the stable optimum. And therefore, the policy instructed by the MDP, given the demand price and marginal costs, is indeed optimal for the finite horizon simulated.

4.3.2. Case study: Recession and economic boom simulations

We established previously the persistent observation of the potential causality effect of big swings in cost level to trigger mergers. When marginal costs of small and large firms are close enough, no substantial synergy is achievable, and thus the market is relatively quiet as shown in (Figure 17) where we reduced the span between the two marginal costs by setting $\beta = \mathcal{U}(0.99,1)$ in

$$c_l = \beta * c_s + \mathcal{N}(0, 10^2)$$

Even though the probability of a merger occurrence was high in years $\in \{2009; 2012; 2014; 2015; 2016\}$, the MDP chooses to merge only in two years $\in \{2009; 2015\}$. Furthermore, in 2009, both merger scenarios have high probabilities, yet the MDP establishes the “stay-put” strategy as a best policy for large firms, while he instructs small firms to merge. Compared to 2015, where the same merger probabilities occur, yet the MDP instructs large firms to merge. We observe though, that the difference in marginal costs among firms, is larger in 2015 than in 2009.

Once we simulate a recession[2] and even though the marginal cost still close enough, mergers are triggered by low prices as depicted in (Figure 18). Moreover, the prices barely change as a result of mergers, but the output level is lowered. We conclude that in the case of a recession there is always an incentive to merge, compared to a stagnant market where the firms’ operational performance, depicted by their marginal cost, is the one-factor element that influences the decision to merge. Less performant firms will either exit the market or swallowed in a takeover. Furthermore, and as established earlier, the MDP may prescribe a “stay-put” strategy as an optimal strategy even though merger conditions are met based on the expected NPV optimisation.

[1] In case of a merger, the sum of the two firms’ value pre-merger added to the value of the new firm post-merger. The result is then weighed proportionally to the capital of the merged firms, to compare with individual small firms’ stand-alone value. Divided by 2 in case of merger, divided by 3 in case of acquisition. Same calculus as the reward matrix.

[2] To simulate a recession, we model the industry demand price with $\mathcal{B}(\mu = -8\%, \sigma = 60\%)$ and the exact opposite for an economic boom $\mathcal{B}(\mu = 8\%, \sigma = 60\%)$

Same findings are observed when simulating an economic boom. How freight rates and marginal costs fluctuate compared to each other is the one key element that influences a rational decision to merge.

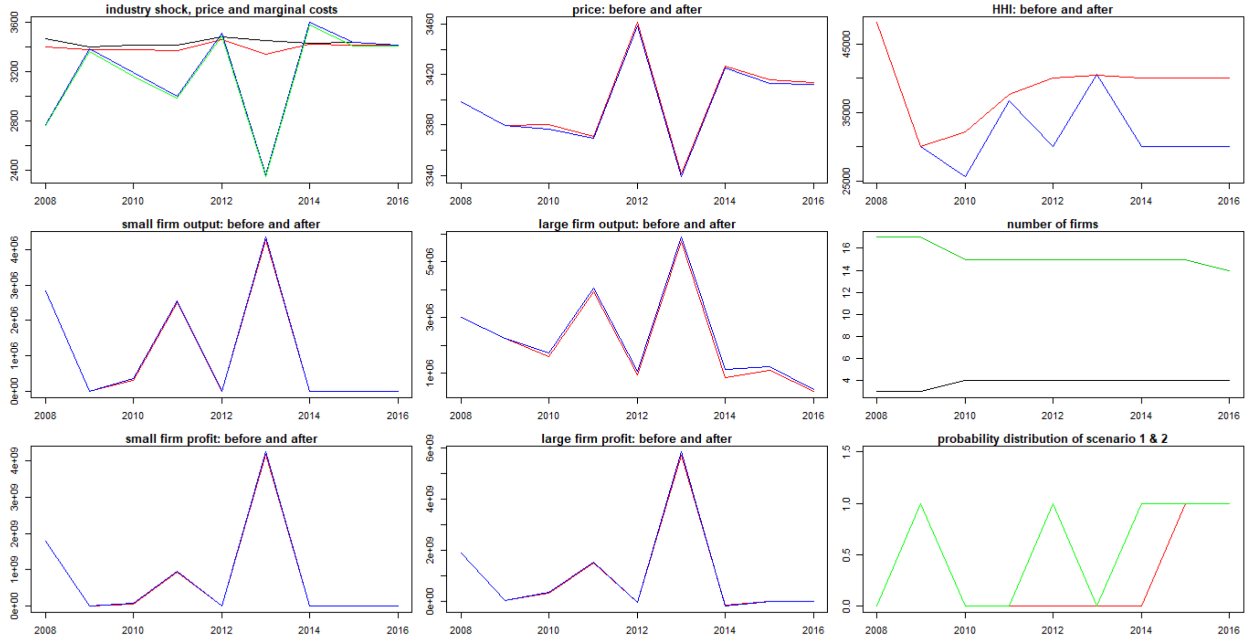


Figure 17: MDP simulation with a small difference in marginal costs between small and large firms. Market structure n=3 oligopolies and m=17 small firms

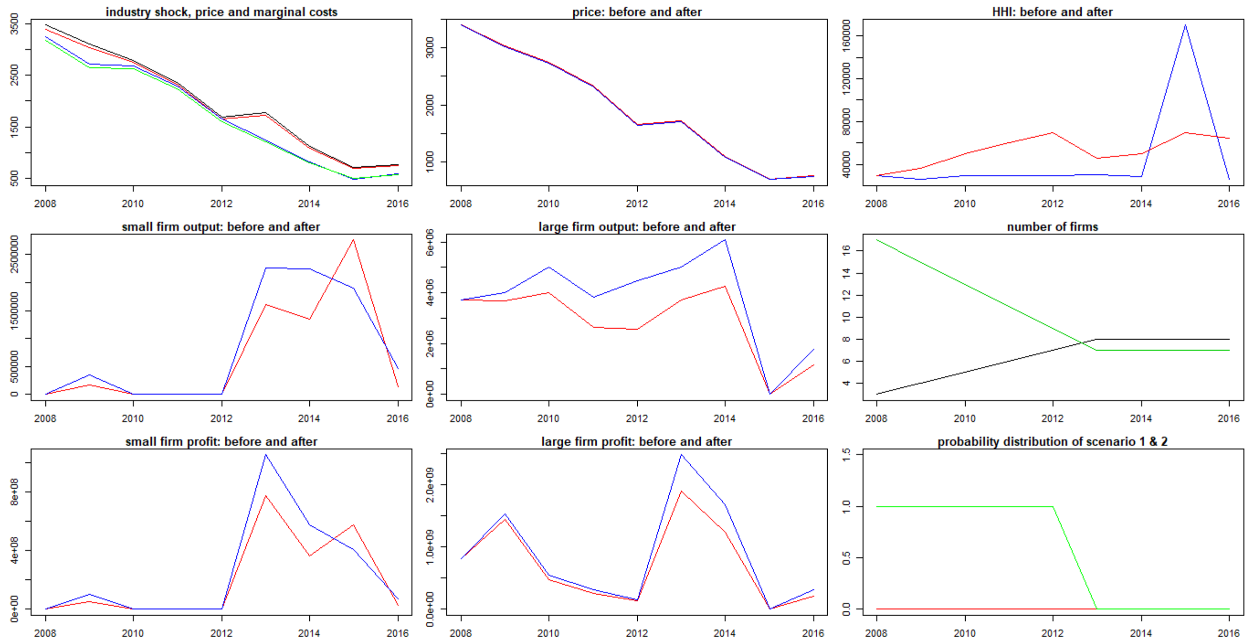


Figure 18: MDP simulation of a recession. Market structure n=3 oligopolies and m=17 small firms

4.3.3. Case study: overpriced premium

In previous sections and for modelling simplification, we assumed the acquirer to only pay for the stand-alone value of the target. In this section, we will introduce the premium in the MDP algorithm. Both the reward and the transition matrices will be updated according to equation (2).

To simulate an overpriced premium, we set premium=120% of the target firm value instead of the initial settings of $\mathcal{N}(49\%; 39\%^2)$ in the deterministic simulation. We tested for both close and loose marginal costs.
The purpose of this simulation is not to assess the performance of firms' post-merger since the actual algorithm does not allow it. But rather to test if, in the case of an over-valued premium, the MDP would still instruct merger as an optimal strategy.

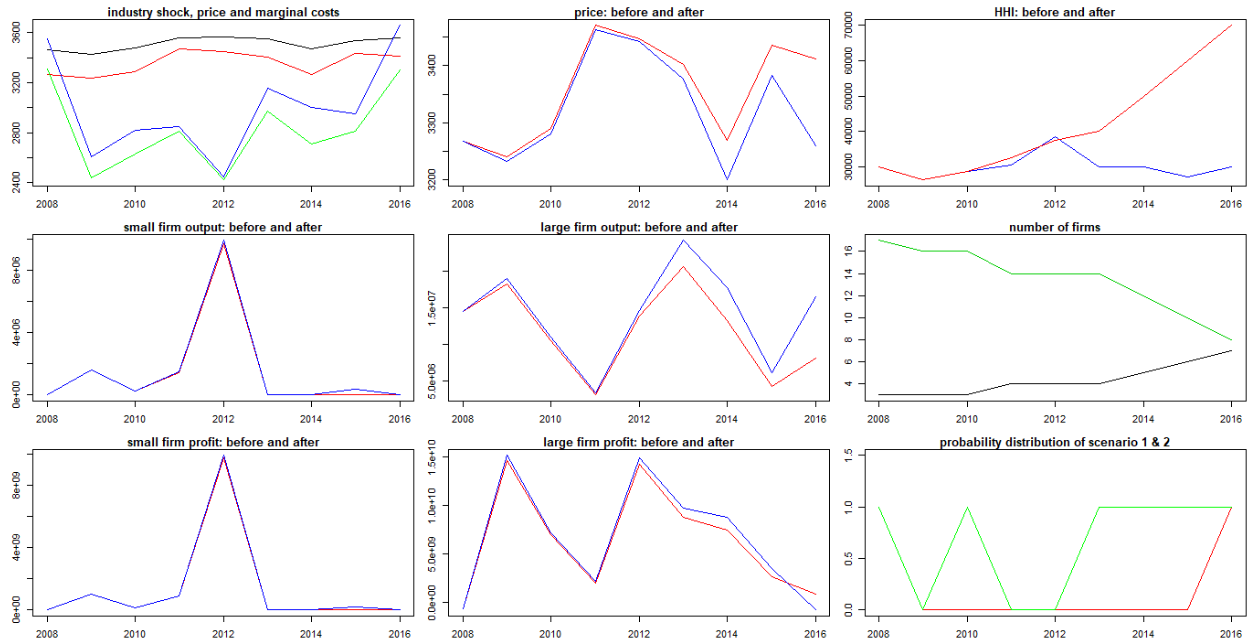


Figure 19: MDP simulation with premium = 120% of the target stand-alone value. Loose marginal costs

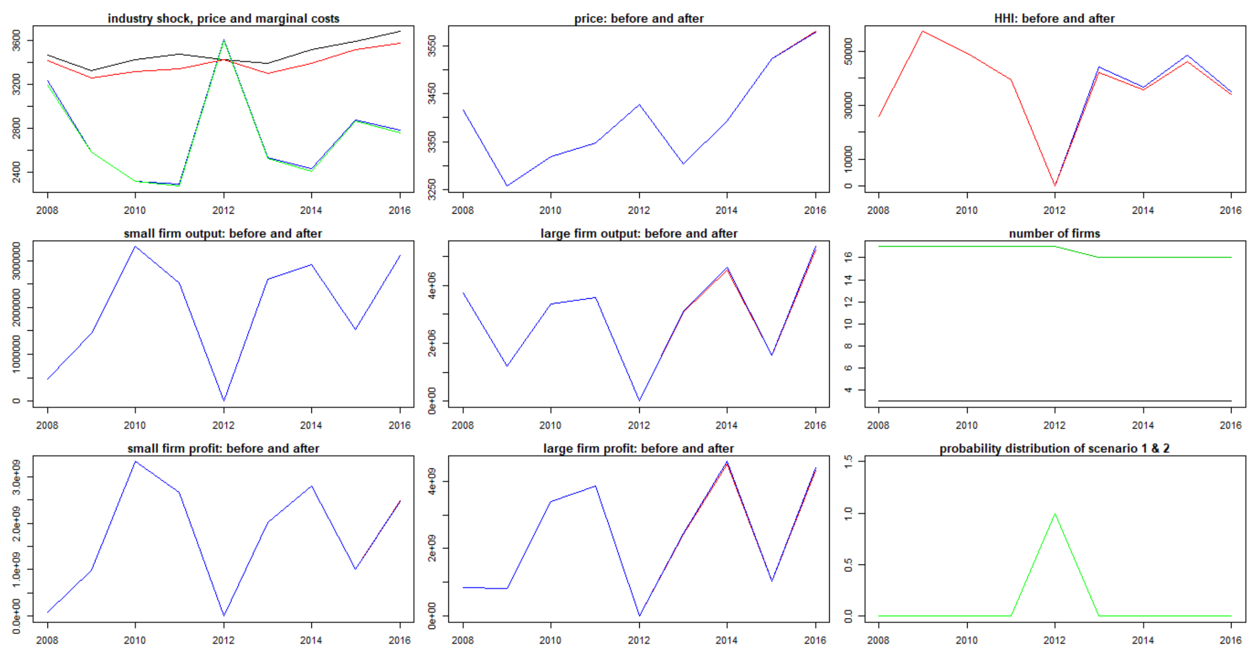


Figure 20: MDP simulation with premium = 120% of the target stand-alone value. Close marginal costs

Again as previously established, the fluctuation of demand and firms' cost performance account the most for the decision to merge as depicted in (Figure 19) and (Figure 20). When assessing the best policy, the amount of paid premium does not influence the MDP substantially. This result is relevant to OOCL's acquisition by COSCO where the latter offered a substantial price-to-book premium of 140% to prevent CMA CGM from any overbidding move.

4.3.4. Case study: Hamburg-Sud takeover by Maersk

In this section, we will assess whether Hamburg-Sud takeover by Maersk was a rational decision based on a real potential of synergy. Like in previous simulations, we will assume a baseline scenario, not optimistic nor pessimistic with no growth assumptions when evaluating the merger[1].

Since Hamburg-Sud data is not available, we will assume that it has the same operational performance as OOCL. From Alphaliner TOP100, we observe that OOCL and Hamburg-Sud have roughly the same capacity. Which may indicate similar costs. Furthermore, Hamburg-Sud's revenue of 2015 and 2016 (respectively $6726 million and $6234 million) approximate OOCL's revenues of the same period (respectively $5953.44 million and $5297.69 million). Therefore, we will use OOCL as an acceptable surrogate of Hamburg-Sud.

To recreate the market in the scope [2008; 2016] and instead of using random variables, we will setup the following variables at their market values[2]: the total demand Q, the price P, the operation costs C, the revenue R. For the WACC value, we will keep the same stochastic configuration as used in previous simulations. Moreover, a bankruptcy of a small firm is forced in 2016 to simulate Hanjin bankruptcy.

Since the econometric model use a two-type structure to simulate the market, we must configure the number of large firms n and small firms m in such a way that at equilibrium, the price P and total demand Q are equal to the given values. To do so, we configure the algorithm given a large firm prototype—in this case Maersk—and a small firm prototype—in this case Hapag-Lloyd—to produce each firm's type individual values.

Using the inverse production function (equation 4), we model the demand price as follows:

$$a = P + b * Q$$

Using the revenue, we compute the output of a firm i:

$$q_i = \frac{R_i}{P}$$

Using the output, we compute the marginal cost of a firm i:

$$c_i = \frac{C_i}{q_i}$$

Next, using $Q = \sum_{i=1}^{n+m} q_i = nq_l + mq_s$ and given a number of large firms n we compute the required number of small firms to supply the given total demand:

$$m = \frac{Q - nq_l}{q_s}$$

We consider firms in the TOP3[3] to be large firms, therefore $n = 3$.

---

[1] Same assumptions used by CMA CGM to access APM acquisition.
[2] Using data from the sources mentioned in subsection "The variables" in methodology section.
[3] Maersk, MSC and CMA CGM

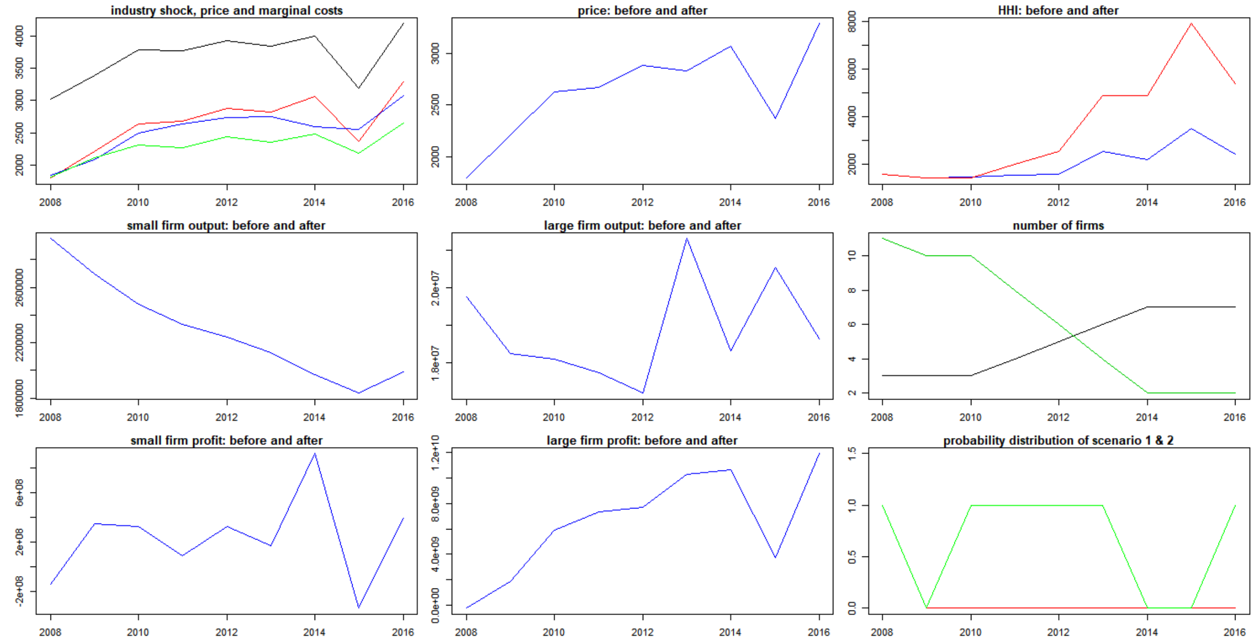


Figure 21: MDP simulation of mergers with real-life market configuration with 3 large firms identical to Maersk and 21 small firms identical to Hamburg-Sud

We observe in (Figure 21) that the MDP instruct Maersk to acquire Hamburg-Sud as an optimal strategy only once in 2008. Beyond that scope, the MDP instructs a “stay-put” strategy for Maersk and a “merge” strategy for Hamburg-Sud from 2010 to 2014. Therefore, Maersk decision to acquire Hamburg-Sud in 2017 instead of 2008 was not an optimal strategy.

Since Maersk did not acquire Hamburg-Sud until 2017, we need assess whether a late acquisition is still optimal. For that we force the algorithm[1] not to allow for M&A activities until 2016 as shown in (Figure 22). We observe two main elements. First, the probability to either merge or acquire is one. Therefore, with regards to the econometric model, both decisions are better than a “stay-put” strategy. However, the MDP chooses to instruct Hamburg-Sud to merge with a small firm—for instance Hapag-Lloyd—as an optimal strategy compared to a takeover by Maersk. We conclude that although, both scenarios achieve synergy, Hamburg-Sud could have secured more value to its shareholders if the merger with Hapag-Lloyd succeeded. The fact that Hamburg-Sud was in talks with Hapag-Lloyd for merger before Maersk’s offer is backed by the MDP as the optimal strategy. However, after the failure of the merger negotiations, Hamburg-Sud considered the second best option: to be acquired by Maersk for a significant premium paid with cash.

[1] We also update the algorithm to show the number of firms at the end of each year instead of the beginning of each year like in previous simulations. The reason is that the merger happens at the end of the horizon

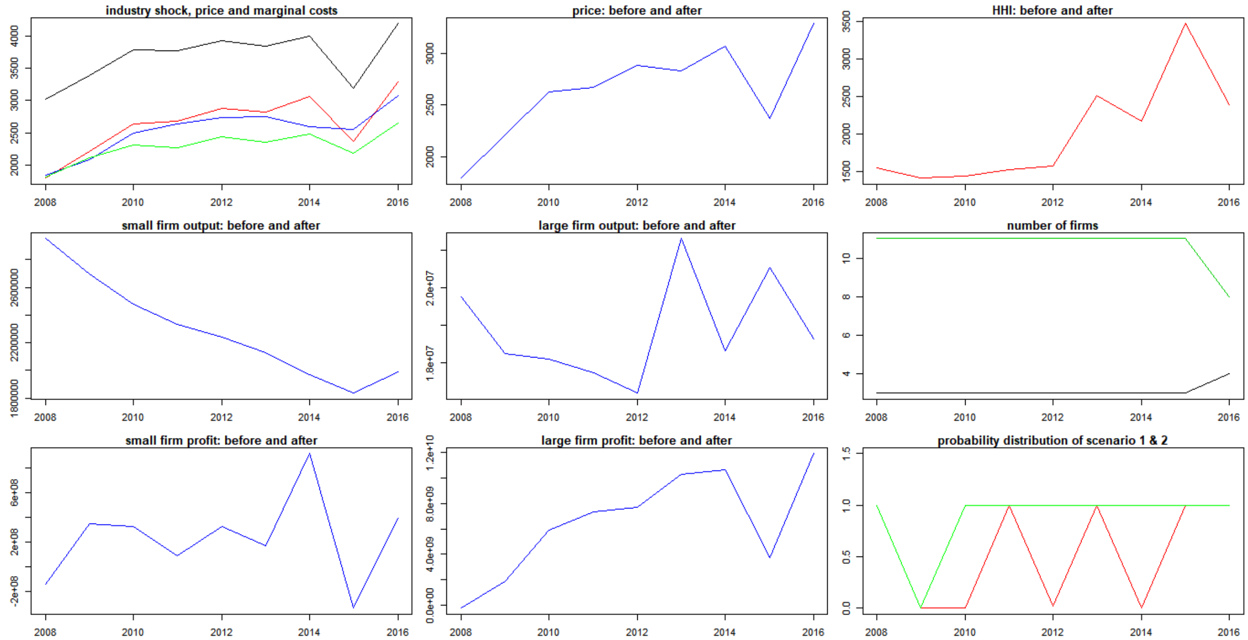


Figure 22: MDP simulation of a late M&A with the same configuration as Figure 21

4.3.5. Case study: OOCL takeover by COSCO

Using the same approach in the previous subsection, we will investigate whether OOCL acquisition by either CMA CGM or COSCO is optimal, since both companies were rumored to be in talks with the target.

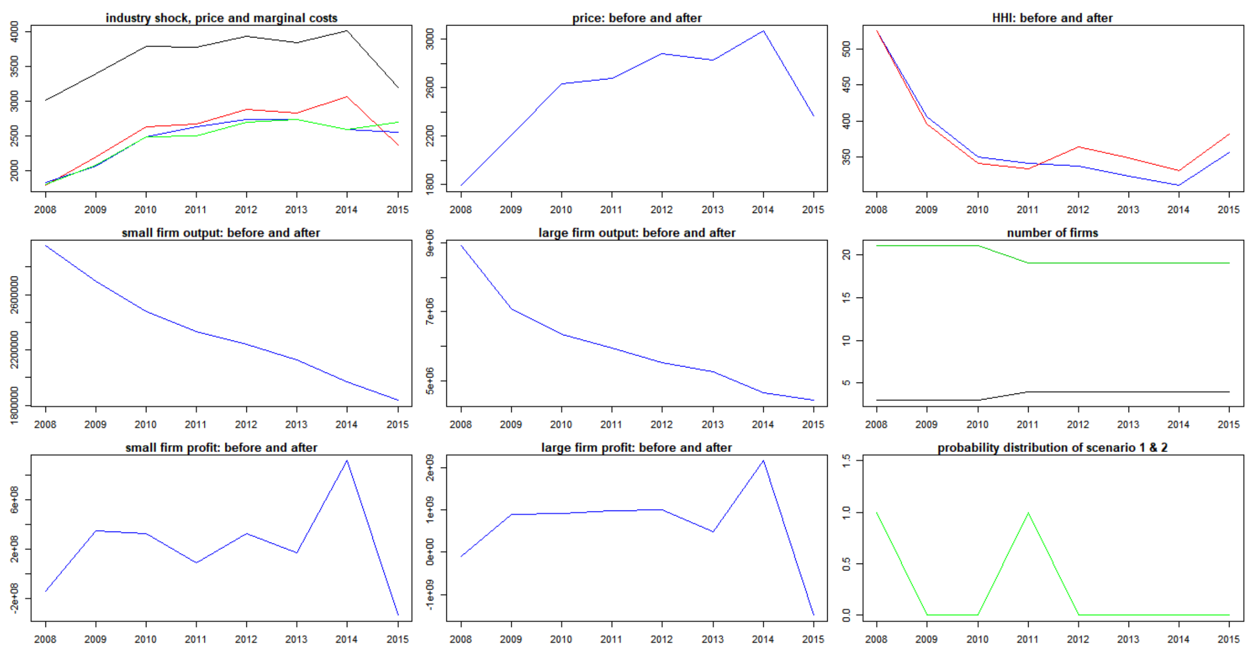


Figure 23: MDP simulation of mergers with real-life market configuration with 3 large firms identical to CMA CGM and 21 small firms identical to OOCL

We observe in (Figure 23), that the MDP instructs CMA CGM not to acquire OOCL. In fact, after its acquisition of APL, the MDP instructs CMA CGM to stay put in a late merger scenario in simulations that included OOCL, Hapag-Lloyd, EVERGREEN, HMM and Yang Ming.

The decision of CMA CGM not to overbid COSCO and to focus instead in growing organically by ordering nine large vessels in 2017 is, according to the MDP, the optimal decision.
(Figure 23) also suggests that CMA CGM's acquisition of APL should have happened earlier[1] than 2015 to maximize the value added to the shareholders.

Next, we will assess OOCL takeover by COSCO. In this case study, we face two issues. In previous simulations, we modelled the large firms with lower marginal costs than the small firms. This assumption does not hold with OOCL and COSCO, since the latter has the highest marginal cost. We force, nonetheless, the algorithm to account for these values. The second issue is that COSCO is not part of the TOP3 and thus, it is not considered a large firm. To solve this shortcoming, we consider the TOP4. Moreover, since we must model for identical large firms similar to COSCO with total capital asset matching the total capital asset of the TOP4, we set the number of large firms equals to $n = 6$.

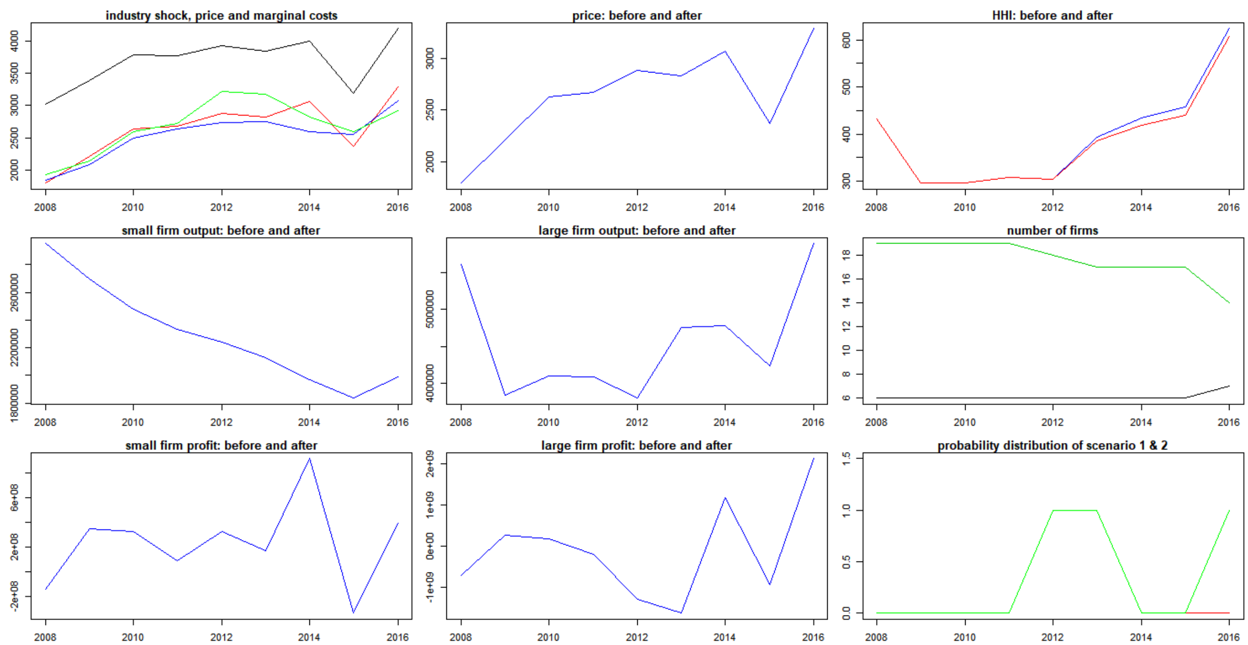


Figure 24: MDP simulation of mergers with real-life market configuration with 6 large firms identical to COSCO and 19 small firms identical to OOCL

The MDP in (Figure 24) instructs COSCO to acquire OOCL in 2012 and 2013. Since COSCO did not acquire OOCL in those years, we need to examine whether a late acquisition is still optimal. As (Figure 25) clearly depicts, OOCL is better off merging with a similar firm such as Hamburg-Sud than acquired by COSCO. In fact, after several simulations with different large firms, the only profitable scenario is to be acquired by Maersk or MSC. Since Maersk already acquired OOCL's sister (Hamburg-Sud), OOCL could have been in a better position if MSC made an offer. This finding explains why COSCO was forced to offer a substantial cash deal of $6.3 billion (31% over OOCL's market value).

Although, COSCO's management and analysts suggest that COSCO can learn from OOCL, the decision to acquire OOCL is not motivated by synergy. OOCL has a niche market and the possibility for COSCO to copy OOCL's performance in other markets, given its size, is very ambitious and cannot be achieved in a short-term basis. We observe though, that other targets,

[1] either in 2008 or 2011

such as Yang Ming, constitute a better deal for COSCO than OOCL. We conclude that COSCO clearly targets a larger market share with the intention to strengthen its market power. The decision may create a value added to the COSCO's shareholders but it destroys market value.

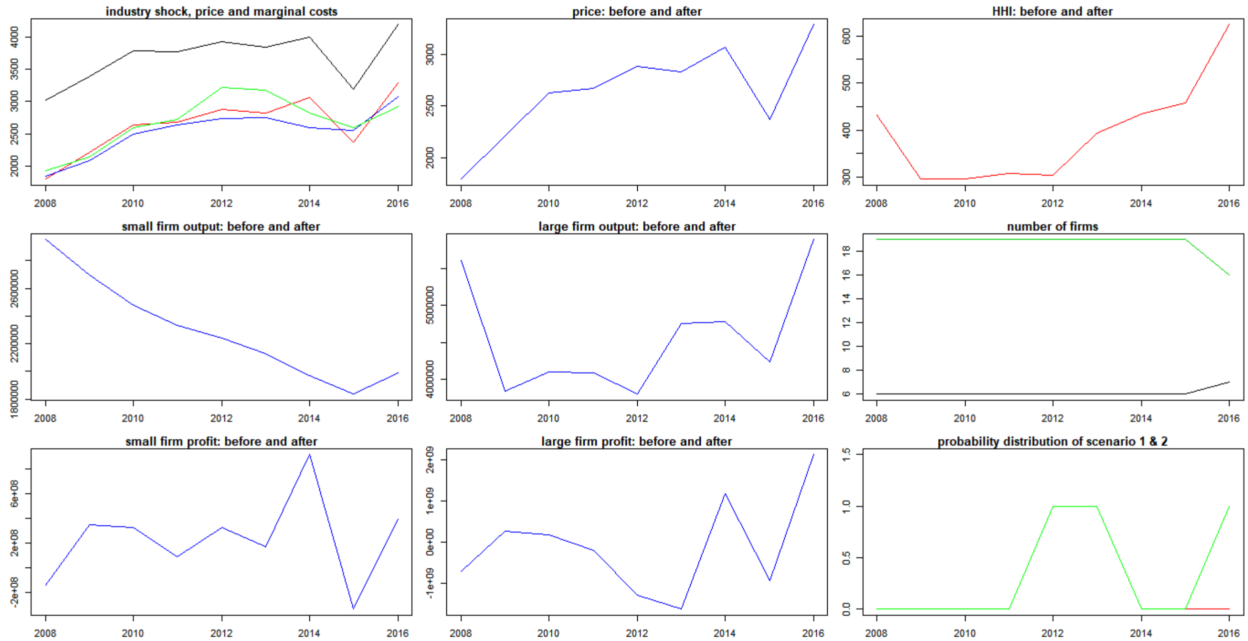


Figure 25: MDP simulation of a late M&A with the same configuration as Figure 24

4.4. Limitations and future research

In this section, we will expose how modelling assumptions—made to overcome challenges to the problem statement—limit the fitness of the model to the life-like state of the world. Possible solutions to overcome these shortcomings are proposed in the last sub-section for future research.

4.4.1. Limitations

While conducting this research, we faced three main challenges.

First, data scarcity is a serious hurdle to our research. It lies on the fact that the majority of container shipping firms are private companies and rarely communicate their data. For instance, to test the hypothesis of the cost function, we need to know the volume of FFE slot sold (q), operating expenses C(q,k) and the capital (k). The latter is difficult to estimate in case of private corporations. One possible solution is, instead of considering the book value of the firm, we use the capital of tangible assets. Also, hard to estimate but not as difficult as the market value. However, since operational costs data are not available either, we will not consider private companies in this simulation[1]. This is a major limitation to this research. The model mimics a sub-market behaviour using global industry shocks. MSC shipping, for instance, has substantial market share and capacity. Its absence from the simulation distorts the MDP equilibrium of the industry output and price compared to the real-life equilibrium values.

Second, we faced poor quantitative literature that addresses M&As in container shipping industry. The majority of available models were conducted for other sectors (telecommunication, US retail

[1] Except for CMA CGM (some data are available)

market) that are not nearly similar to freight shipping sector. Bridging this literature gap was one of the research objectives.
Modelling also presented some other challenging aspects. For instance, the constant marginal cost results in a formulation of profit, and so the NPV, that is independent of the level of capital engaged in producing output. Therefore, outputs are not capacitated by the capital[1]. From 2008, container shipping experienced severe overcapacity which means that for our scope we can consider unlimited capacity. However, beyond that scope and with further data, we notice the relevance of a quadratic expression to model costs.
Another modelling issue is that taxes and capital depreciation are not addressed. Not that we judge their impact as relevant to the decision-making process of M&As in container shipping, but to simulate how all market conditions together influence M&As, we sense the relevance to include them in future research.
Moreover, the modelling horizon has to be finite. Since this research does not address market entry and one state is an absorbing state, the steady state of the MDP will converge to "bankruptcy" state. To avoid this situation, the question research addressed impact in a finite horizon.

Finally, to simplify merger modelling, we had to set restrictions in the algorithm. Following the approach of (Hackbarth and Miao 2012), we assumed a two-type market structure with agents who make decisions independently of each other. As a result, we were forced to limit the number of possible mergers to a maximum of one per year if no bankruptcy occurs. Such restrictions are not valid in container shipping market as portrayed in (Table 2). Moreover, we assumed that total synergy took place in the following year of the merger. In real-life cases, synergy takes several years to translate into cash inflows.

4.4.2. Future research

The next step for future research is to establish the boundaries of marginal cost and prices for a firm to consider either, internal growth, expansion by M&As or to exit the market. The simulation, provided some minor improvements, would sketch optimal policy settings that include assets investment.
Furthermore, the demand price needs to be modelled beyond the scope 2008-2016, to capture the cyclicality of the market and so allow for a deeper analysis on how cyclicality triggers merger waves in container shipping industry. It is also possible to model different parallel markets[2] and to link them to study the impact of economies of density using real marginal costs[3].
Finally, to assess in a concrete way the impact of premiums on the performance of mergers post-merger, the algorithm needs to be updated to account for cash flow history matrix. Such settings will also allow assessing the risk of bankruptcy.

[1] Mainly assets in the context of maritime industry
[2] Since each trade (Europe-Asia trade, Pacific trade, Atlantic trade) has different intrinsic price, demand and elasticity variables
[3] Mostly banker price

5. Conclusion

In the aftermath of the economic recession, maritime sector struggled with high volatility. Container shipping, in particular, finds itself caught in a spiral of war prices since Maersk introduced the Triple-E class to the market. As shippers' demand was lagging behind liners' appetite for bigger ships, the market could not cope with the growing capacity glut, and soon freight rates dived to historic lows. Although maritime industries are familiar with cyclicality, the last low cycle proved to be tougher, and many companies in the TOP20 did not make it through 2016. They were either swallowed in an acquisition or forced to exit the business.

Such market dynamics triggered the interest to investigate the following research question:
"In a finite horizon, what is the impact of the financial status and operations' performance on the probability of merger, acquisition or market exit in container shipping sector."

To answer the problem statement, we decided on a call option model. A widely used approach to value M&As likelihood. To mimic decision-making under uncertainty, we coupled the call option model with an MDP to simulate M&As market dynamics based on operations' management performance. The latter is captured through cost structure. We choose to conduct simulation for its flexibility to model all possible states of the world with as few assumptions as possible.

One of these assumptions is the Two-type market structure that we must consider to avoid a cumbersome model. We believe though that this assumption is not without credit. Based on marginal costs values and the fleet size, liners can be classified into two types of players, the TOP3 as large firms and the reaming fringe as small firms.

The second assumption is that firms are assumed rational and make decisions independently of other peers' strategy. We find that the latter has little to no impact in our MDP for two main reasons. First, considering the possibility of a firm engaging in merger just to retaliate to a peer or for hubris, the firm cannot proceed with this merger unless it has an economic base. Such condition is guaranteed by the board and the shareholders' approval and to some extent, the legal and financial advisors assistance. Secondly, we consider that firms are solely concerned with profit maximisation. The econometric model focuses on the expected synergy as the main factor that influences the decision to merge. We do not assume agency theory nor hubris since they are not straightforward to model.

The model counts another assumption that is a fixed amount of capital available in the market. Although we could simulate market exits, we did not include new entries to the market. It follows that our simulation does not model a contestable market.

Through modelling and simulation, we were able to establish a number of findings. First, we established the flat marginal cost structure of container shipping and showed how sunk, and fixed costs are negligible compared to marginal costs. Both findings signal a mature industry.

Furthermore, this study verifies that demand and marginal costs fluctuation are key factors to M&As' occurrence. Performing firms survive low demand while the less performing is forced to merge or to exit the business.
We simulated the long run perfect market equilibrium, and the results reveal that container shipping tends towards a natural monopoly as predicted by (Haralambides 2004) especially when the spread among firms' marginal cost is significant. Most importantly, the simulations show that in the long run, M&As do not cause prices to rise. Indeed, prices surge in the short run as a mechanism to bring the market back to a new equilibrium after an M&A occurrence, but they tend

to go back to their initial expected values in the long run. Therefore, we conclude that price escalation after M&As is not a true valid sign of growing market power.

In the short run scenario, simulations of the unstable equilibrium reveal less likeliness of mergers due to differential efficiency theory compared to neoclassical operating synergy theory. We observe that symmetric mergers prevail compared to asymmetric mergers even if we assume the large firm wins the acquisition bid over the small one in a multi-bidder scenario. We find these results have a strong and intuitive logical base. An acquiring firm cannot engage in a takeover unless it is a profitable bargain. If the target is poorly managed, it must translate into its cost function which will boost the expected synergy of the takeover. However, experience showed that this is not the case of all mergers. OOCL, for instance, is an excellent performer in container shipping with almost no losses during the scope of research. However, it is being acquired by COSCO who has higher marginal costs.

Afterwards, we established that although the premium may impact the performance of the merging firms' post-merger as many literature support, it does not influence the decision to merge.

Moreover, the MDP simulations support the first-mover advantage with no positive externality for non-participating firms. Both these findings contradict (Hackbarth and Miao 2012). It is tempting to invoke the cost structure adjustments and the merger probability densities to justify the discordance with (Hackbarth and Miao 2012). We resolved to consider a benchmark model to verify these divergences and opted for (Mason and Weeds 2010). The motive behind this choice is that Mason and Weeds use a similar call option model to assess irreversible investment under uncertainty. Their model does not require any cost function but rather embody the profits as a stochastic variable. This feature makes Mason and Weeds' model neutral with regards to cost structure assumptions. The findings of (Mason and Weeds 2010) are in accordance with our results in (Table 5). We, therefore, refute the "free riding problem" and the late call option as an optimal strategy in the context of container shipping.
Also, in contrast with (Hackbarth and Miao 2012), we relaxed the fixed capital supply in the market and allowed for bankruptcies. However, (Figure 16) depicts no bankruptcy occurrence. Therefore, we can exclude the assumption of the fixed capital supply overtime as possible discrepancy factor that led to contradicting (Hackbarth and Miao 2012) in the last two findings.

Finally, recession and economic boom modelling need further research with a capacitated model to capture to the best the dynamics of prices.

Bibliography

Aguerrevere, F.L. (2003) 'Equilibrium Investment Strategies and Output Price Behavior: A Real-Options Approach', *The Review of Financial Studies* 16(4): 1239-1272.

Alphaliner, 2017. *Weekly Newsletter 12.04.2017 to 18.04.2017,* (16), pp. 3.

Alphaliner 'PublicTop100'. Accessed 7/9 2017 <https://alphaliner.axsmarine.com/PublicTop100/>.

Altman, E.I. (1968) 'Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy', *The journal of finance* 23(4): 589-609.

Auerbach, A.J. and D. Reishus (1988) 'Taxes and the Merger Decision', *Chapter* 19: 300-313.

Baldi, F. and L. Trigeorgis 'Valuing Synergies from Business Combinations and Testing Goodwill for Impairment: A Real Options Approach'.

Berg, S.V., J. Duncan and P. Friedman (1982) *Joint Venture Strategies and Corporate Innovation.* Oelgeschlager, Gunn & Hain.

Bernheim, B.D. and M.D. Whinston (1990) 'Multimarket Contact and Collusive Behavior', *The Rand journal of economics* : 1-26.

Bertola, G. and R.J. Caballero (1990) 'Kinked Adjustment Costs and Aggregate Dynamics', *NBER macroeconomics annual* 5: 237-288.

Brakman, S., H. Garretsen and C. Van Marrewijk (2005) 'Cross-Border Mergers and Acquisitions: On Revealed Comparative Advantage and Merger Waves'.

Brealey, R.A., S.C. Myers, F. Allen and P. Mohanty (2012) *Principles of Corporate Finance.* Tata McGraw-Hill Education.

Cabral, L.M. (2017) *Introduction to Industrial Organization.* MIT press.

Chahine, S. and A. Ismail (2009) 'Premium, Merger Fees and the Choice of Investment Banks: A Simultaneous Analysis', *The Quarterly Review of Economics and Finance* 49(2): 159-177.

Chevalier-Roignant, B., C.M. Flath, A. Huchzermeier and L. Trigeorgis (2011) 'Strategic Investment Under Uncertainty: A Synthesis', *European Journal of Operational Research* 215(3): 639-650.

Choudhury, M.A. (1994) *Economic Theory and Social Institutions: A Critique with Special Reference to Canada.* University Press of America.

Dangl, T. (1999) 'Investment and Capacity Choice Under Uncertain Demand', *European Journal of Operational Research* 117(3): 415-428.

Davidson, I. (1985) 'Takeovers: Partitioning of Gains and Pareto Improvement in a Rational Market with Asymmetric Information', *Journal of Business Finance & Accounting* 12(3): 373-385.

DePamphilis, D.M. (2013) *Mergers, Acquisitions, and Other Restructuring Activities : An Integrated Approach to Process, Tools, Cases, and Solutions.* (Seventh edition. edn) Amsterdam : Academic Press,.

Dick, A.R. (2004) 'If Cartels were Legal, when would Firms Fix Prices', *How Cartels Endure and How They Fail: Studies of Industrial Collusion, Cheltenham, UK: Edward Elgar* : 144-173.

Fusillo, M. (2009) 'Structural Factors Underlying Mergers and Acquisitions in Liner Shipping', *Maritime Economics & Logistics* 11(2): 209-226.

Garcia, F. and R. Sabbadin (2001) 'Solving Large Weakly Coupled Markov Decision Processes: Application to Forest Management', *Ghassemi, F., et al* : 1707-1712.

Gomes-Casseres, B. (2003) 'Competitive Advantage in Alliance Constellations'.

Gordon, G.J. (1999) 'Approximate Solutions to Markov Decision Processes', *Robotics Institute* : 228.

Green, R.J. and D.M. Newbery (1992) 'Competition in the British Electricity Spot Market', *Journal of political economy* 100(5): 929-953.

Greenwood, R. and S.G. Hanson (2014) 'Waves in Ship Prices and Investment', *The Quarterly Journal of Economics* 130(1): 55-109.

Hackbarth, D. and J. Miao (2012) 'The Dynamics of Mergers and Acquisitions in Oligopolistic Industries', *Journal of Economic Dynamics and Control* 36(4): 585-609.

Hall, B.H. (1988) 'The Effect of Takeover Activity on Corporate Research and Development', 'The Effect of Takeover Activity on Corporate Research and Development', *Corporate Takeovers: Causes and Consequences,* pp. 69-100. University of Chicago Press.

Haralambides, H.E. (2004) 'Determinants of price and price stability in liner shipping', Workshop on The Industrial Organization of Shipping and Ports, National University of Singapore, pp5-6.

Harford, J. (2005) 'What Drives Merger Waves?', *Journal of Financial Economics* 77(3): 529-560.

Hayward, M.L. and D.C. Hambrick (1997) 'Explaining the Premiums Paid for Large Acquisitions: Evidence of CEO Hubris', *Administrative Science Quarterly* : 103-127.

Jovanovic, B. and P.L. Rousseau (2008) 'Mergers as Reallocation', *The review of economics and statistics* 90(4): 765-776.

Kandelaki, I. (Last updated 2017) 'Mergers and Acquisitions in Container Shipping Industry'. Accessed August/16 2017 <https://www.linkedin.com/pulse/mergers-acquisitions-container-shipping-irakli-kandelaki>.

Kayo, E.K., H. Kimura, M.R. Patrocínio and Oliveira Neto, Luis Elesbão de (2010) 'Acquisitions, Joint Ventures Or Arm's-Length Alliances? Analyzing the Determinants of the Choice of Growth Strategy in Brazil from 1996 through 2007', *BAR-Brazilian Administration Review* 7(4): 397-412.

Knowler, G. (2016) 'Japanese Shipping Merger to Create New Major Liner', *Journal of Commerce* : n/a.

Lambrecht, B.M. (2004) 'The Timing and Terms of Mergers Motivated by Economies of Scale', *Journal of Financial Economics* 72(1): 41-62.

Li, X., R.A. Zuidwijk, M. de Koster and R. Dekker (2016) 'Competitive Capacity Investment Under Uncertainty'.

Malmendier, U. and G. Tate (2008) 'Who Makes Acquisitions? CEO Overconfidence and the Market's Reaction', *Journal of Financial Economics* 89(1): 20-43.

Marathe, R.R. and S.M. Ryan (2005) 'On the Validity of the Geometric Brownian Motion Assumption', *The Engineering Economist* 50(2): 159-192.

Margsiri, W., A.S. Mello and M.E. Ruckes (2008) 'A Dynamic Analysis of Growth Via Acquisition', *Review of Finance* 12(4): 635-671.

Markowitz, H. (1952) 'Portfolio Selection', *The journal of finance* 7(1): 77-91.

Mason, R. and H. Weeds (2010) 'Investment, Uncertainty and Pre-Emption', *International Journal of Industrial Organization* 28(3): 278-287.

Mitchell, M.L. and J.H. Mulherin (1996) 'The Impact of Industry Shocks on Takeover and Restructuring Activity', *Journal of Financial Economics* 41(2): 193-229.

Moeller, S.B., F.P. Schlingemann and R.M. Stulz (2005) 'Wealth Destruction on a Massive Scale? A Study of Acquiring-firm Returns in the Recent Merger Wave', *The Journal of Finance* 60(2): 757-782.

Mukherjee, T.K., H. Kiymaz and H.K. Baker (2004) 'Merger Motives and Target Valuation: A Survey of Evidence from CFOs'.

Neary, J.P. (2016) 'International Trade in General Oligopolistic Equilibrium', *Review of International Economics* 24(4): 669-698.

Neary, J.P. (2003) 'Globalization and Market Structure', *Journal of the European Economic Association* 1(2-3): 245-271.

Nelson, R.L. and National bureau of economic research (Etats-Unis) (1959) *Merger Movements in American Industry, 1895-1956.* Princeton University Press Princeton.

Nielsen, L.T. (1992) *Understanding N (D1) and N (D2): Risk-Adjusted Probabilities in the Black-Scholes Model.* INSEAD.

Palepu, K.G. (1986) 'Predicting Takeover Targets: A Methodological and Empirical Analysis', *Journal of Accounting and Economics* 8(1): 3-35.

Paris, C. and P. Page (2017) 'Maersk Line, Hapag-Lloyd among Carriers Subpoenaed in U.S. Price-Fixing Probe.', *Wall Street Journal (Online)* .

Perry, M.K. and R.H. Porter (1985) 'Oligopoly and the Incentive for Horizontal Merger', *The American Economic Review* 75(1): 219-227.

Powell, W.B. (2011) *Approximate Dynamic Programming : Solving the Curses of Dimensionality.* (2nd ed. edn) Hoboken, N.J. : Wiley,.

Puterman, M.L. (2014) *Markov Decision Processes: Discrete Stochastic Dynamic Programming.* John Wiley & Sons.

Rau, P. and S. Spinler (2016) 'Investment into Container Shipping Capacity: A Real Options Approach in Oligopolistic Competition', *Transportation Research.Part E, Logistics & Transportation Review* 93: 130.

Reuer, J.J. (1999) 'Collaborative Strategy: The Logic of Alliances', *Mastering strategy* 4: 12-13.

Reynaerts, J. (2010) 'Simulating Mergers between Stevedores', *Maritime Economics & Logistics* 12(1): 8-35.

Routley, K.D. (2015) *, A markov game model for valuing player actions in ice hockey* .

Sirower, M.L. (1997) *The Synergy Trap: How Companies Lose the Acquisition Game.* Simon and Schuster.

Sødal, S., S. Koekebakker and R. Aadland (2008) 'Market Switching in shipping—A Real Option Model Applied to the Valuation of Combination Carriers', *Review of Financial Economics* 17(3): 183-203.

Stigler, G.J. (1950) 'Monopoly and Oligopoly by Merger', *The American Economic Review* 40(2): 23-34.

Sys, C. (2009) 'Is the Container Liner Shipping Industry an Oligopoly?', *Transport Policy* 16(5): 259-270.

Villalonga, B. and A.M. McGahan (2005) 'The Choice among Acquisitions, Alliances, and Divestitures', *Strategic Management Journal* 26(13): 1183-1208.

Wright, R. and S. Jung-a (2016) 'Hanjin Bankruptcy Brings Chaos but no Capacity Cut', *FT.com* : n/a.

Annex A

1. Maersk OLS data analysis

Units as described in “Dataset description” section.

firm	year	revenue	costs	TEU sold	EV	price	log_revenue	log_costs	log_EV	log_price	log_TEU	FFE	log_FFE
maersk	2016	35464	35690	20830000	45098.96	1795	10.476273	10.482626	10.716614	7.49276	16.8519	10415000	16.15876
maersk	2015	40308	38438	19044000	36203.04	2209	10.604305	10.556802	10.496898	7.700295	16.76226	9522000	16.06912
maersk	2014	47569	41652	18884000	52484.67	2630	10.769937	10.637105	10.868276	7.874739	16.75383	9442000	16.06068
maersk	2013	47386	40050	17600000	61093.41	2674	10.766082	10.597884	11.020159	7.891331	16.68341	8800000	15.99026
maersk	2012	49523.1	41826.25	17017600	51120.5	2881	10.810195	10.641279	10.841941	7.965893	16.64976	8508800	15.95661
maersk	2011	60227.38	49955.75	16200000	46675.51	2828	11.005882	10.818893	10.750975	7.947325	16.60052	8100000	15.90737
maersk	2010	56108.32	45502.57	14600000	55373.58	3064	10.935039	10.725524	10.921858	8.027477	16.49653	7300000	15.80338
maersk	2009	48640.14	44874.08	13800000	52132.89	2370	10.792204	10.711616	10.861551	7.770645	16.44018	6900000	15.74703
maersk	2008	61215.14	49313.15	14000000	40340.89	3284	11.02215	10.805946	10.605121	8.096817	16.45457	7000000	15.76142

2. Maersk Log OLS for costs, FFE slot sold and Enterprise Value

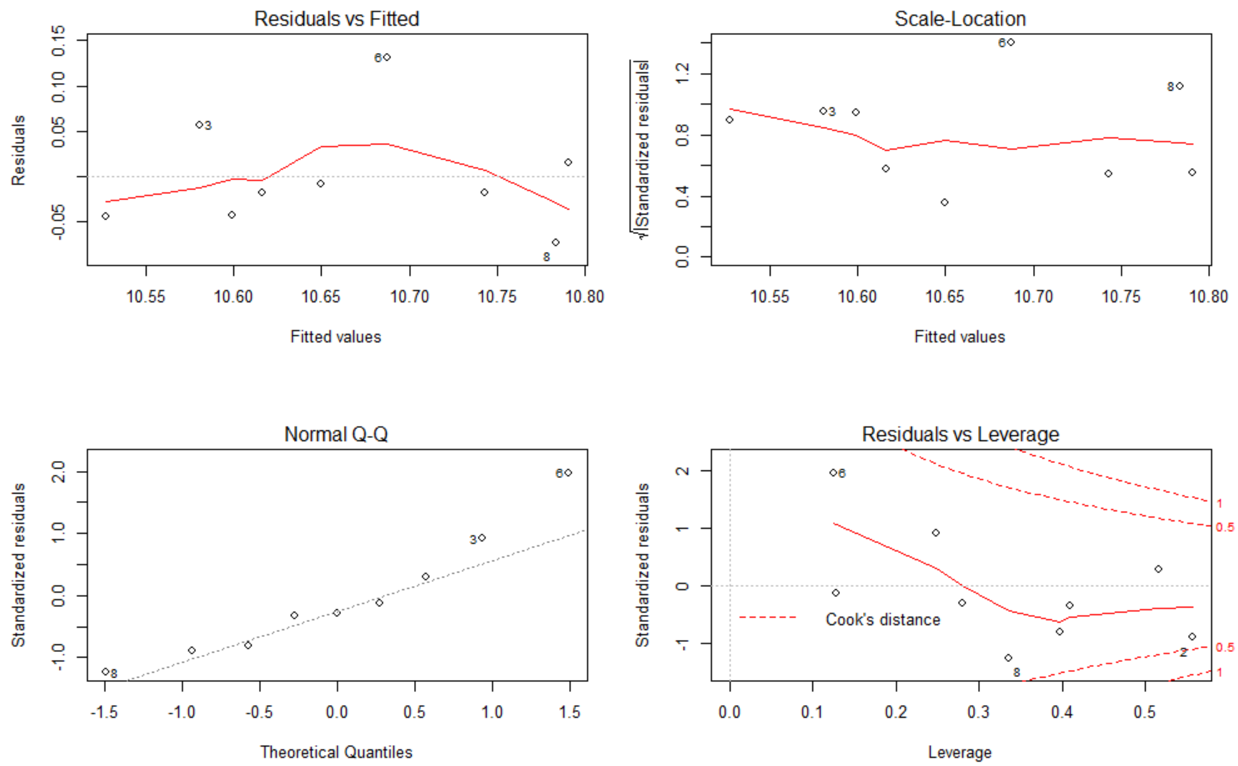
```
Residuals:
     Min       1Q   Median       3Q      Max 
-0.07211 -0.04229 -0.01787  0.01495  0.13167 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) 21.66452    3.47361   6.237 0.000786 ***
log_FFE     -0.64640    0.17449  -3.704 0.010035 *  
log_EV      -0.06462    0.15688  -0.412 0.694739    
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.07122 on 6 degrees of freedom
Multiple R-squared:  0.6962,	Adjusted R-squared:  0.595 
F-statistic: 6.875 on 2 and 6 DF,  p-value: 0.02803


ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
Level of Significance =  0.05 

                     Value p-value                Decision
Global Stat        3.83917  0.4282 Assumptions acceptable.
Skewness           1.75973  0.1847 Assumptions acceptable.
Kurtosis           0.04687  0.8286 Assumptions acceptable.
Link Function      1.87912  0.1704 Assumptions acceptable.
Heteroscedasticity 0.15346  0.6953 Assumptions acceptable.
```



3. Peers’ Log OLS with revenue proxy.

The price entry is omitted since no data available for peers. Only Maersk communicates an annual estimate.

Hapag-Lloyd:

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.27592    1.21847   0.226 0.829817
log_revenue  0.87359    0.11140   7.842 0.000541 ***
log_assets   0.07365    0.18777   0.392 0.711071
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.05824 on 5 degrees of freedom
  (1 observation deleted due to missingness)
Multiple R-squared:  0.9656,    Adjusted R-squared:  0.9519
F-statistic:  70.2 on 2 and 5 DF,  p-value: 0.0002193


ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
Level of Significance =  0.05
                      Value p-value                Decision
Global Stat        1.735363  0.7843 Assumptions acceptable.
Skewness           0.581753  0.4456 Assumptions acceptable.
Kurtosis           0.001207  0.9723 Assumptions acceptable.
Link Function      0.149590  0.6989 Assumptions acceptable.
Heteroscedasticity 1.002812  0.3166 Assumptions acceptable.
```

COSCO:

```
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  -3.1426     3.1372  -1.002 0.355144
log_revenue   0.8561     0.1358   6.304 0.000743 ***
log_assets    0.2902     0.2104   1.379 0.217115
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.08777 on 6 degrees of freedom
Multiple R-squared:  0.8779,    Adjusted R-squared:  0.8372
F-statistic: 21.57 on 2 and 6 DF,  p-value: 0.001821


ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
Level of Significance =  0.05

                     Value p-value                   Decision
Global Stat        4.69499 0.32005    Assumptions acceptable.
Skewness           0.06424 0.79992    Assumptions acceptable.
Kurtosis           0.33828 0.56083    Assumptions acceptable.
Link Function      4.15626 0.04148 Assumptions NOT satisfied!
Heteroscedasticity 0.13622 0.71207    Assumptions acceptable.
```

Evergreen:

```
Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)   1.2063     1.0223   1.180   0.2826
log_revenue   0.6119     0.1840   3.326   0.0159 *
log_assets    0.2370     0.1850   1.281   0.2475
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.06194 on 6 degrees of freedom
Multiple R-squared:  0.8929,    Adjusted R-squared:  0.8572
F-statistic: 25.01 on 2 and 6 DF,  p-value: 0.001228


ASSESSMENT OF THE LINEAR MODEL ASSUMPTIONS
USING THE GLOBAL TEST ON 4 DEGREES-OF-FREEDOM:
Level of Significance =  0.05

                   Value p-value                Decision
Global Stat        8.599 0.07194 Assumptions acceptable.
Skewness           3.460 0.06288 Assumptions acceptable.
Kurtosis           1.134 0.28686 Assumptions acceptable.
Link Function      2.299 0.12950 Assumptions acceptable.
Heteroscedasticity 1.706 0.19145 Assumptions acceptable.
```

Annex B

Display of the 30 first liner from the Alphaliner TOP100. For the complete listing please refer to Alphaliner website.

		Total		Owned		Chartered		Orderbook	
Rank	**Operator**	**Teu**	**Ships**	**TEU**	**Ships**	**TEU**	**Ships**	**TEU**	**Ships**
1	**APM-Maersk**	**3,523,225**	**656**	**1,711,114**	**245**	**1,812,111**	**411**	**296,690**	**22**
2	**Mediterranean Shg Co**	**3,057,506**	**504**	**1,082,557**	**190**	**1,974,949**	**314**	**170,050**	**15**
3	**CMA CGM Group**	**2,450,347**	**484**	**914,214**	**117**	**1,536,133**	**367**	**140,786**	**15**
4	**COSCO Shipping Co Ltd**	**1,804,594**	**325**	**493,079**	**81**	**1,311,515**	**244**	**521,020**	**30**
5	**Hapag-Lloyd**	**1,520,485**	**217**	**1,016,413**	**117**	**504,072**	**100**	**14,993**	**1**
6	**Evergreen Line**	**1,031,713**	**192**	**548,041**	**105**	**483,672**	**87**	**304,378**	**33**
7	**OOCL**	**655,746**	**100**	**427,574**	**54**	**228,172**	**46**	**107,065**	**5**
8	**Yang Ming Marine Transport Corp.**	**587,815**	**98**	**209,150**	**45**	**378,665**	**53**	**70,000**	**5**
9	**Hamburg Süd Group**	**555,943**	**102**	**313,508**	**46**	**242,435**	**56**	**30,640**	**8**
10	**NYK Line**	**538,101**	**95**	**238,574**	**40**	**299,527**	**55**	**126,104**	**9**
11	**MOL**	**524,251**	**77**	**220,676**	**26**	**303,575**	**51**	**60,470**	**3**
12	**PIL (Pacific Int. Line)**	**372,226**	**139**	**298,819**	**120**	**73,407**	**19**	**142,200**	**13**
13	**Zim**	**357,207**	**75**	**27,800**	**6**	**329,407**	**69**		
14	**K Line**	**347,354**	**59**	**80,150**	**12**	**267,204**	**47**	**69,350**	**5**
15	**Hyundai M.M.**	**346,715**	**60**	**159,369**	**21**	**187,346**	**39**		
16	**Wan Hai Lines**	**235,194**	**90**	**169,598**	**71**	**65,596**	**19**	**15,200**	**8**
17	**X-Press Feeders Group**	**150,492**	**96**	**24,622**	**21**	**125,870**	**75**		

18	**KMTC**	**121,100**	**59**	**60,236**	**29**	**60,864**	**30**		
19	**SITC**	**99,534**	**75**	**69,644**	**50**	**29,890**	**25**		
20	**IRISL Group**	**94,387**	**44**	**94,387**	**44**			**58,000**	**4**
21	**Zhonggu Logistics Corp.**	**94,168**	**81**	**50,329**	**23**	**43,839**	**58**	**20,000**	**8**
22	**Arkas Line / EMES**	**70,456**	**41**	**64,711**	**37**	**5,745**	**4**	**12,400**	**4**
23	**Simatech**	**67,063**	**23**	**23,505**	**9**	**43,558**	**14**		
24	**Sinotrans**	**67,013**	**41**	**22,768**	**14**	**44,245**	**27**	**5,838**	**3**
25	**Quanzhou An Sheng Shg Co**	**65,891**	**45**	**63,172**	**39**	**2,719**	**6**	**38,640**	**20**
26	**TS Lines**	**64,984**	**32**	**3,386**	**2**	**61,598**	**30**	**5,424**	**3**
27	**Transworld Group**	**54,991**	**34**	**32,165**	**20**	**22,826**	**14**		
28	**Emirates Shipping Line**	**49,237**	**10**			**49,237**	**10**		
29	**UniFeeder**	**49,013**	**45**			**49,013**	**45**		
30	**SM Line Corp.**	**48,315**	**14**	**43,555**	**10**	**4,760**	**4**		
31	**Salam Pasific**	**48,243**	**50**	**48,243**	**50**			**700**	**1**
32	**Heung-A Shipping**	**46,883**	**37**	**13,384**	**16**	**33,499**	**21**		
33	**Sinokor**	**46,275**	**39**	**24,869**	**21**	**21,406**	**18**		
34	**Grimaldi (Napoli)**	**43,905**	**40**	**40,063**	**39**	**3,842**	**1**		
35	**Matson**	**43,310**	**26**	**40,534**	**22**	**2,776**	**4**	**14,200**	**4**
36	**Swire Shipping**	**42,894**	**29**	**33,146**	**22**	**9,748**	**7**		

Annex C

Date	98469 World Container Exports Million TEU
1996	46.78
1997	50.77
1998	54.12
1999	59.92
2000	66.77
2001	69.94
2002	75.68
2003	84.07
2004	95.23
2005	105.09
2006	116.87
2007	129.44
2008	134.71
2009	122.37
2010	139.17
2011	149.99
2012	154.64
2013	162.53
2014	171.21
2015	175.05
2016	181.01
2017	188.76

Annex D

Simulation graph legend starting from left to right

row	graph title	variable	color
1	industry shock, price and marginal costs	a (demand price)	black
		P (price)	red
		c_s (small firm marginal cost)	blue
		c_l (large firm marginal cost)	green
	price: before and after	P (price before merger)	blue
		P (price after merger)	red
	HHI: before and after	HHI (before merger)	blue
		HHI (after merger)	red
2	small firm output: before and after	q_s (before merger)	blue
		q_s (after merger)	red
	large firm output: before and after	q_l (before merger)	blue
		q_l (after merger)	red
	number of firms	n (large firms)	black
		m (smal firms)	green
3	small firm profit: before and after	π_s (before merger)	blue
		π_s (after merger)	red
	large firm profit: before and after	π_l (before merger)	blue
		π_l (after merger)	red
	probability distrbution of scenario 1 &2	probability scenario 1	green
		probability scenario 2	red