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EXPLORATORY STUDY ON OIL STORAGE VALUATION

BACHELOR THESIS

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PREFACE

An important part of the Dutch GDP is directly or indirectly generated in the Port of Rotterdam, and the port currently still is the number one port in Europe. My fascination for the Port of Rotterdam started last year. Organizing a student event in the Rijnhaven introduced me into the world of the Port of Rotterdam. I have learned to drive a Kalmar reach stacker, was involved in the logistics of 150 sea containers and got introduced with several big port companies and their inspiring people.

In my opinion, students in Rotterdam are not aware of the importance of the port and therefore lack interest for this fascinating part of Rotterdam. On the other hand, the Port of Rotterdam doesn't undertake the steps necessary to get student involved. I fell in love with the port, and that is exactly the reason I want to write my Bachelor Thesis with the Department of Port Economics.

INTRODUCTION

Over the years, LNG storage valuation has been major subject of research. At the same time, there has been a lack of attention for the valuation of storage facilities in the oil industry. Due to deregulations, the oil (as well as LNG) storage services are now a separated business service from the sales and transportation services[1]. Furthermore, the spot and futures markets of oil have been subject to heavy development, which is attracting more and more activity to these markets. The combination of deregulation and developing oil markets is causing storage trading decision and price fluctuations to intertwine. Buyers and sellers of crude oil have the possibility to use storage capacity to take advantages of the volatility in prices. For example, it could be profitable to store an oil possession for another month because of price fluctuations. These new developments indicate a need for new research and extended knowledge on the valuation of oil storage.

In principle, storage is needed to ensure the security of supply. Efficient and reliable oil storage is crucial for cooping and managing the fluctuations in supply and demand. Traditionally, these fluctuations were caused by increased demand in the winter months for heating purposes. Over the years, the traditional pattern changed due to peak summer power demand and a continually adjusting energy market, contributing to demand fluctuations.

Research concerning the valuation of oil storage facilities has been falling behind compared to the growing importance of oil storage. As Boogert and De Jong state: "the issue of storage valuation is not limited to gas markets. Storage also plays a significant role in, for example, oil markets."[2] Since LNG and oil storage valuation shows a lot of similarities, this paper will use research within the field of LNG storage valuation as a base to extend the knowledge on valuation of oil storage.

This paper will use the same terminology as used in previous literature. Previous literature made a clear distinction between the owner of an storage facility and the operator. The owners actually own the facility, while the operator might rent a part from the owner in order to use it. Note that an owner might also operate a facility. Furthermore, an oil terminal is an oil storage facility. These terms will both be used and are synonymic.

Since there is almost no academic literature on the valuation of oil storage facilities (terminals), what do companies use to valuate their oil terminals? Looking at oil storage valuation, one should start with analyzing the annual reports of oil storage companies to analyze the way they valuate their oil storage facilities. This paper analyzed the following annual reports: Royal Vopak N.V. 2009,

[1] (Boogert & De Jong, Spring 2008, p. 81)
[2] (Boogert & De Jong, Spring 2008, p. 81)

Odfjell 2009, Marquard & Bahls AG (OilTanking) 2008, and "Klaus Oil"[3] 2009. As expected, oil storage facilities are valuated according to internationally accepted accounting standards like IAS and IFRS. As Royal Vopak N.V. describes: "Property, plant and equipment are broken down into their components and carried at historical costs, net of accumulated straight-line depreciation on expected useful life and taking into account the expected residual value and impairments."[4] In practice, companies break up their oil storage terminals into four main components: ground, tank shelf, top, and installations & accessories. These four main components are depreciated using different expected useful life and expected residual value for each component. Combined with the historical costs, this generally makes up the value of an oil storage facility on the balance sheet of companies operating within oil storage.[5] This implies that the valuation is based on historical costs, which could be named as an accounting approach.

Financial valuation is always based on the principle that an asset value is equivalent to its expected future cash flows.[6] This implies that there is a difference between the valuation according to accounting rules and valuation using financial principles. Academic research showed several future cash flow models applied on the valuation of LNG storage facilities. Future cash flow models (financial approach) have been used to valuate oil storage facilities, but are not publically accessible. Companies operating within the oil storage industry (like Royal Vopak N.V.) use cash flow models, but keep them confidential because these investment models often incorporate an important part of their core business. Academic research should have been focusing on closing this knowledge gap, but has failed so far.

Looking at the current situation in the oil markets and taking the general financial principle into account, one would expect that oil storage facility's cash flows are dependent on the crude oil prices. Especially since academic research showed proof concerning LNG. However, according to Royal Vopak N.V. "there is no connection between the value of an oil storage facility (terminal) and the price of crude oil."[7] People within the industry argue that the value of an oil storage facility for the owner is determined by the strategic location of the facility, not by the price of oil. The strategic locations are scarce since there are only a few hubs over the world. Examples of important hubs are: ARA (Amsterdam-Rotterdam-Antwerp), Houston, and Singapore. According to owners like Royal Vopak N.V., these hub locations determine the value of an oil terminal, not the price of oil.

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[3] Disguised case due to confidentiality
[4] (Royal Vopak N.V., 2009, p. 88)
[5] (Rietvelt, 2010)
[6] (Koller, Tim; Goedhart, Marc; Wessels, David, 2005)
[7] (Rietvelt, 2010)

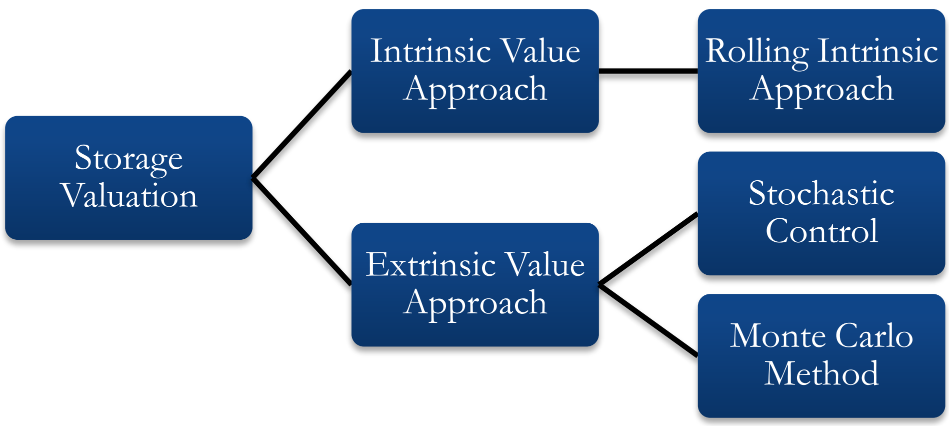
In practice, owners of oil storage facilities (terminals) rent out the storage space they have to operator. Generally, terminals owners rent out space per cubic meter for a fixed rent over three or five years. In additional, owners of terminals charge fees for additional services like for example heating, blending and distillation. Therefore, terminal owners have a very steady income stream that is almost predetermined for the next three to five years. Logically, terminals owners (like Royal Vopak N.V.) argue that there is no connection between the value of their terminal and the price of crude oil.

Most LNG research papers argue that their LNG research might also apply to the crude oil market. All the LNG storage facility valuation research relates directly or indirectly to the spot of future price of LNG. If it is true that the valuation of oil storage facilities has no relation to the price of crude oil, then the useful LNG research could not be applied to crude oil.

This paper will examine whether or not a connection between the value of an oil storage facility and the price of crude oil can be identified. If a connection can be found, future research could use findings within the field of LNG to try to further develop the valuation of oil storage facilities (terminals). To clarify, the paper will focus on the valuation of a terminal form the owner's point of view.

Research literature has had a strong focus on different valuation techniques that can be used for valuating LNG storage facilities. This paper will give a short overview of research and findings within this field with the purpose of extending the knowledge on valuation of oil storage.

A LNG storage operator owns the flexibility to inject and withdraw LNG at any moment in the future. Given that the prices for LNG fluctuate, the task of the operator is to find the optimal operation of the storage to maximize profits. This implies that the value of the facility is dependent on current and expected LNG prices. Two characteristics of prices within the energy market allow storage operators to maximize its profitability: predictable price movements, known as seasonality effects, and unpredictable price fluctuations. The latter effect is also known as price volatility.



The most basic approach to storage valuation is to calculate the optimal position given the available price curve on the forward market and the spot market, and take this position. The approach is called the *intrinsic value approach* and captures the predictable seasonal pattern in energy prices and therefore secures a sure profit. Additional value that can be created by reacting upon the fluctuation in the spot market is known as the *extrinsic value approach*. A storage operator can choose between forward-based valuation (intrinsic), or speculating on the spot market and perform a spot-based valuation (extrinsic).

In the field of the intrinsic value approach, the most known study is by Gray and Khandelwal (2004). They propose a rolling intrinsic approach by which the operator captures the intrinsic value of its position at the start of the contract. When the prices change and the new forward prices arrive, the operator determines whether the profit of unwinding its current position and taking on a new optimal position based on the new prices outweighs the transaction costs of this action.[8] The real option theory provides the framework needed for making optimal operation decisions.[9] The rolling intrinsic approach is a very safe and secure strategy, which is an advantage. The major disadvantage is that this strategy is not profit maximizing. This is first of all caused by prices of consecutive periods, when a new position would make sense, are often strongly correlated. Secondly, the volatility of the forward market is often relatively small, which implies that the impact of taking on a new position remain small. Therefore, this strategy is not profit maximizing which implies that it is not the optimal strategy. Maragos (2002) described a new variant on the concept of Gray and Khandelwal. He introduced the variant in which the operator only adjusts the spot trades to the new information on the forward market.[10] The operate takes a position in both the forward and the spot market. As soon as both forward and spot prices fluctuate, the operator determines whether or not it is profitable to adjust the position in the spot market, but the operator holds his forward position. This simplification allowed Maragos to incorporate operational constraints. For example, every time gas is injected or withdrawn, the pumps of the facility use some of the stored LNG as fuel. Therefore, Maragos' strategy is more realistic, but even less profit maximizing then the concept of Gray and Khandelwal. Research by Gray and Khandelwal, and Maragos describes most research done within forward-based or intrinsic valuation.

Advantages Extrinsic Value Approach

- Spot market as a base
- Spot market more volatile than forward market
- Easier to include Operational constraints

Disadvantages Extrinsic Value Approach

- Prediction of future fluctuations

[8] (Gray & Khandelwal, 2004)
[9] (Thompson, Davidson, & Rasmussen, 2008)
[10] (Maragos, 2002)

Research on spot-based valuation (extrinsic) is more complicated than theory on forward-based valuation. Three advantages for spot-based valuation can be named. First, all gas and oil must be traded through the spot market, making it the base for trade. Forwards and futures are derivatives of the spot market, exposing the derivative market to a certain amount of basic risk. The second reason is a consequence of the "Samuelson effect".[11] The consequence is that prices on the forward market are much less volatile than on the spot market, especially for energy products. Since the value of storage facilities is caused the variability in prices, it makes more sense to use the spot market for the valuation. Third, it is more difficult to incorporate operational factors like injection and withdrawal rate of a storage facility, when forward market trades are incorporated.[12] The difficulty of spot-based valuation is the actual prediction of future fluctuations op the spot market, a common problem in the broader field of finance. Therefore, the base for the spot-based valuation of energy storage facilities can be traced back to more general financial theory like the real option approach (as named earlier). Approaches to this problem differ. Two popular approaches for the valuation of the spot-based strategy are: stochastic control theory and the Monte Carlo method.

Stochastic control theory is related to the modeling and control of dynamic system influenced by stochastic disturbances and uncertainties. Dynamic control system refers to a time series in which every value is influenced by the previous value. This time series is disturbed by random noise of uncertainties. In contrast to deterministic signals, random signals cannot be described as given functions of time such as a step or a sine wave. The exact function is unknown to the system designer; only some of its average properties are known. This stochastic control theory is used to predict "random" processes like the future spot prices. Thompson, Davidson and Rasmussen (2003) applied the stochastic control approach to storage valuation. Their models are based on Bellman equations that are solved using a finite difference method. Finite difference methods are numerical methods used in mathematical finance for the valuation of options.[13] Using this method, Thompson et al. created realistic price dynamics and operational characteristics allowing their model to directly account for high, unexpected price volatilities. A disadvantage of using a stochastic control is that it implies a direct link between the stochastic price process and the optimal strategy. Therefore, it might cause biased results and wrongly estimated valuations.

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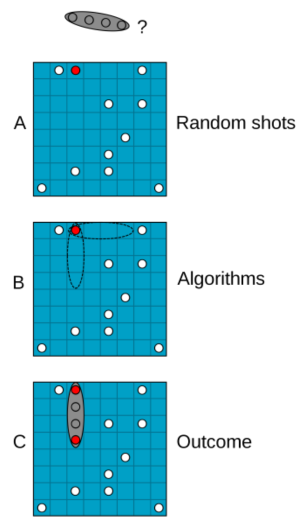
[11] (Samuelson, 1965)

[12] (Thompson, Davidson, & Rasmussen, 2008)

[13] (Hull J. C., 2002)

In the Monte Carlo method, the stochastic price process and the optimal strategy separated. This implies that the Monte Carlo approach leaves room for quick experiments with different price processes. Another advantage is the ease to incorporate additional operational constraints[14], which is very useful when it comes to valuating storage facilities. Monte Carlo methods (or Monte Carlo experiments) are a class of computational algorithms that rely on repeated random sampling to compute their results. So, it is used to solve various problems by generating random numbers using random sampling of the probability distribution given as an input in the model. Then the Monte Carlo method produces hundreds of thousands of possible outcomes. Finally it aggregates the wide range of results of individual computations into a narrow final result. It is tend to be used when it is unfeasible or impossible to compute an exact result with a deterministic algorithm, like unpredictable spot prices. [15]



The Monte Carlo method can be illustrated as a game of Battleship to clarify this model a bit more. First the player will make a few random shots. As soon he has a 'hit', he will start applied the algorithms to determine his next move. Given that a battleship covers four dots in horizontal or vertical direction, the next best shot to take down the ship can be obtained. Finally the player will use the random sampling and the algorithm to determine the most likely locations of the opponent's other ships.

In 1977, Boyle applied the Monte Carlo simulation techniques to price European-style options because these simulations are specifically useful in situations with multiple stochastic factors. A ground-breaking research that made way for multiple applications, but European-style option valuation isn't feasible to storage facility valuation. As stated earlier, storage valuation is based on the assumptions that the operator can withdraw and inject at any moment in the future, so a Monte Carlo application on American option is needed. Monte-Carlo methods are harder to use with American options, because the method valuates the option assuming a given starting point and time. However, for early exercise, one would also need intermediate option values. With the Black & Scholes model, these intermediate values are easy to obtain because the simulation runs backwards from an expiration date. For the Monte Carlo method, these values are very hard to obtain. The solution was proposed by Tilley (1993). He demonstrated "the existence of a useful algorithm for valuing American options in a path simulation model should remove what has been perceived as a

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14 (Boogert & De Jong, Spring 2008)

15 (TU Delft, 2009)

major impediment to the use of simulation models in valuing a broker-dealer's derivatives book and in analyzing the asset-liability condition of financial intermediaries."[16] Tilley's research provides the information needed to use the Monte Carlo method for the valuation of American option.

Then in 2001, Longstaff and Schwartz developed a more practical Monte Carlo method for pricing American-style options. They used the Least Squares Monte Carlo (LSM) method to solve American option pricing by simulation.[17] To elaborate on the LSM, valuing American options is characterized by the option holder's decision, at each exercise time, whether to exercise the option or to wait. This decision depends on the comparison between (i) the amount of money that can be obtained if the option is exercised (the immediate exercise value) and (ii) the amount of money that can be obtained if the option is exercised at a future date (the continuation value). Therefore, the optimal exercise decision relies on the continuation value of the American option. The LSM approach estimates this value by a least-squares regression jointly with the cross-sectional information provided by Monte Carlo simulation. These best fitted values of these regressions are used as the expected continuation values. Using the continuation value and the value of immediate exercise, the LSM approach identifies the optimal decision. This exact procedure is repeated going back in time for every exercise time. Discounting the obtained cash flows to time zero, the price of the American option is found. One drawback of the LSM method is that it doesn't give reliable results for valuations with higher dimensions, e.g. when discrete dividends are considered or with multi-state variables options.[18] Nevertheless, the method is appropriate when the binominal method renders and therefore offers a practical valuation method. Hence, it became possible to apply the method on storage valuation, and allowed for experiments with different price processes which is hard using stochastic control.

Since the research by Longstaff and Schwartz, LSM has been applied to several problems with the energy sector. It has been used in the valuation and optimal operation of power plants[19], as well as valuing swing options[20]. With respect to LNG, De Jong and Walet (2003) applied the LSM to value storage, but did not mention details on the implementation in reality.[21] Therefore, Boogert and De Jong (2008) included operational constraints to their research, because in practice, the volume level of the actual terminal determines which actions concerning injection and withdrawal. They state that therefore "the problem is more complex than standard American … options."[22] They propose a

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[16] (Tilley, 1993)
[17] (Longstaff & Schwartz, 2001)
[18] (Areal, Rodrigues, & Armada, 2008)
[19] (Peterson & Gray, 2004), (Tseng & Barz, 2002)
[20] (Ghiuvea, 2001), (Keppo, 2004), (Thanawalla, 2005)
[21] (De Jong & Walet, 2003)
[22] (Boogert & De Jong, Spring 2008)

generalized form of the LSM with a pricing algorithm that includes a solution to deal with the volume variable and the various operational constraints. The downside of their research is that their models assumes a one-factor price process and is therefore only feasible on the short-term, while financial decisions often have long-term perspective[23]. It also is a source for approximation errors in variables[24], which would lead to the biased result over the long term. This disadvantage is a direct result of the dimensionality problem of LSM as named earlier.

The one-factor price disadvantage of the model presented by Boogert & de Jong should be neutralized to make this approach of storage valuation a realistic model to valuate storage terminals. Chen & Forsyth (2010) extended the solid base Boogert and De Jong created by adding seasonality to the long-term equilibrium price. Herewith they made de solution more feasible for the long-term.[25] Although Chen & Forsyth extended the LSM method, the dimensionality problem of LSM is still a drawback of the method and it needs more research.

Schluter and Davidson (2010) argue that existing models are not adequate to capture the reality, using TTF day-ahead gas price as a test. They introduce a new continuous-time price model (applied on LNG) in which the volatility parameter follows GARCH diffusion. A GARCH model is a very complicated model based on volatility. The intuitive idea is that volatility change only gradually over time, such that σ_t^2 will be close(ly related) to σ_{t-1}^2.[26] This combination results in subsequently incorporated in a PDE-based (partial differential equation) algorithm[27] for pricing a gas storage facility. The advantage of their model is that it eases for operational constraints, terminal conditions, different cost structures, as well as multi-factor pricing[28]

As shown, research has focused on the valuation of LNG storage facilities. Literature on oil storage facilities has been falling behind over the years. To start with a short overview on oil storage literature, Prewitt (1942) wrote about oil storage facilities. The article focused on storage facilities being part of the total system of crude oil logistics and ignored the value of a facility gains by trading.[29] Then, Lautier (2003) looked at the information value of future prices, with the purpose of better understanding of the behavior of term structure of commodity prices.[30] He used a Schwartz model[31], which is based on the stochastic behavior of commodity prices. But, also the informational

[23] (Boogert & De Jong, Spring 2008)
[24] (Schluter & Davidson, 2010)
[25] (Forsyth & Chen, 2010)
[26] (Van Dijk, 2010)
[27] (Hull J. , 1999)
[28] (Schluter & Davidson, 2010)
[29] (Prewitt, 1942)
[30] (Lautier, 2003)
[31] (Schwartz, 1997)

value of future prices provides little information for the valuation of oil facilities. In 2006, Bhargava and Goel[32] wrote about the valuation of crude oil being inventory. Although this relates to the valuation of the facilities that stores the inventory, it does not cover the need for the valuation of the storage facility. Others like Casassus and Collin-Dufresne (2005),Trolle and Schwartz (2008) and Andrews (2009) presented models to investigate crude oil future prices and clarify the volatility of the prices in relation to the underlying asset. Current literature might relate to the valuation of oil facilities, but none of the existing literature covers the actual valuation of oil facilities. Therefore, this paper will try to identify the relationship between price of crude oil and the value of oil storage facilities so that future research could use findings within the field of LNG to try to further develop the valuation of oil storage facilities (terminals).

[32] (Bhargava & Goel, 2006)

METHODOLOGY

The research question of this paper has to be in line with the problem statement. That means, finding evidence for an indication for the suspected connection between the value of an oil storage terminal and the price of oil. The first option that springs to mind to identify this relation is to compare the value of existing terminals based on financial principles with the price of crude oil over a long period of time. The problem is that companies that own terminals keep the financial value of these terminals confidential, because this information is part of their core business. Therefore, it impossible to compare the financial value of several terminals to the crude oil price in order to proof the connection. This paper will therefore use a different approach and only try to indentify an indication for the connection.

Royal Vopak N.V. is an established company in the oil storage industry. The company owns 80 companies spread out over 31 countries with a total capacity of 28,594,960 cubic meters[33]. Royal Vopak N.V.'s core business is the storage of oil products. They also offer extra services like blending different products of crude oil in order to comply with the demands of the market. Royal Vopak N.V. is trying to enter the market of LNG. They are going to be involved in a new LNG terminal in Rotterdam in corporation with Gasunie, but this terminal will not be operational until 2011. Therefore, this paper assumes that Royal Vopak N.V. is an excellent example of an owner of oil storage facilities for this analysis. Oil storage terminals are Royal Vopak N.V.'s core business. That being said, if there is connection between the value of an oil terminal and the price of crude oil, then there should also be a connection between the value and profitability of Royal Vopak N.V. and the price of crude oil. Brent Crude Oil Spot Price will be used as the price for crude oil in this analysis. Brent Crude is the biggest of many major classifications of oil and is sourced from the North Sea. The Crude Brent oil market is used to price two thirds of the world's internationally traded oil supplies[34]. Therefore the spot price of Brent Crude is fairly reliable variable for the model being used in this paper. Data is available on a daily basis starting May 1987.

To identify the connection, this paper will perform two different analyses. Since the paper is trying to identify the relation it is better to investigate more than one indication. The first indication this paper will investigate is the relation between the 'Earnings Before Interest, Taxes, Depreciation and Amortization' (EBITDA) of Royal Vopak N.V. over the years and the price of crude oil. One would expect that if there is a connection between the price of crude oil and the value of an oil terminal, that there would also be an influence of the crude oil price on the EBITDA of Vopak.

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[33] (Royal Vopak N.V., 2010)

[34] (U.S. Energy Information Administration, 2010)

Given that oil terminals are Royal Vopak N.V.'s core business. This paper will compare the semi-annual EBITDA of Royal Vopak N.V. with the average semi-annual crude oil price in order to find an indication. The semi-annual EBITDA is available through Thomson One Banker starting from year 1999. The usage of 'Income before income taxes' for this paper was also considered. A downside of "Income before income taxes' the vulnerability for incidental costs and revenues. Furthermore, EBITDA is internationally recognized as a measure for profitability of a company. Thus, this paper assume that Royal Vopak N.V.'s EBITDA is a more reliable variable than the usage of 'Income before income taxes'.

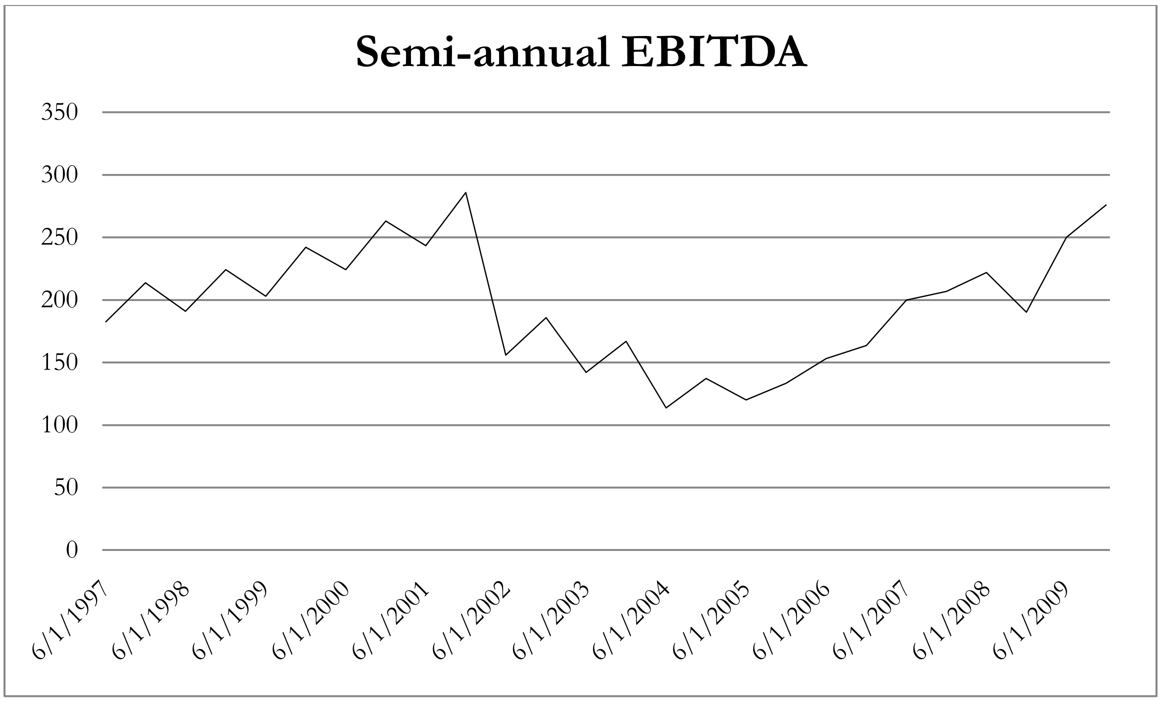
After trying to find an indication for the connection with profitability, this paper will also try to find a connection between the value of Royal Vopak N.V. and the price of crude oil. Oil terminals are by far the most important asset Vopak owns. The oil terminals are Royal Vopak N.V.'s core business and therefore account for almost 70% of the total assets on the balance sheet. Thus, the value of Royal Vopak N.V. as a whole is very dependent on the value of the oil terminals. If the oil terminals will increase significantly in value, one would expect that the value of Royal Vopak N.V. as a whole would also increase. Royal Vopak N.V. is a listed company that is publically traded in EUR on the Euronext Amsterdam Stock Exchange (AEX). To investigate a possible connection between the price of crude oil and the value of Royal Vopak N.V. this paper will compare the spot price of a Royal Vopak N.V. stock with the price of crude oil. The spot prices of Royal Vopak N.V. are available from April 11, 1999 till July 7, 2010. The large sample of data will create a solid base for this analysis. For this research, it is expected that the value analysis will give a more reliable indicator than the profitability analysis. First of all, this study is looking for indicators for relationship between the price of crude oil and the value of an oil terminal, not the profitability. Second, the value analysis will incorporate a much bigger data sample than the profitability analysis. However, the profitability indicator could support the suspected relation and it therefore investigated.

Many people would argue that there is a relationship between the price of crude oil and the AEX in general. On top of that, one would expect a relation between the stock listed on AEX and the AEX itself. Since a circular relation could be expected, a control analysis is needed. This paper will compare the AEX rate with the price of crude oil to control for the analysis of the value indicator. It is expected Royal Vopak N.V. stock is more strongly correlated with crude oil than the AEX index. This paper will examine this as a control for the second indicator.

The paper will start with analyzing the data that will be used as the variables in the several comparisons to find the indicators. Then it will continue to use Ordinary Least Squares (OLS) linear regression to compare the several variables in order to find proof for the expected relationships. OLS is the method that should be used to find the optimal intercept and slope coefficient using a linear regression.[35] Since this paper is trying to proof a linear relationship between the price of oil and the value of oil terminal, OLS is the best method to use. When considering the output of the regression, the paper will use $\alpha=0.05$ as level of significance.

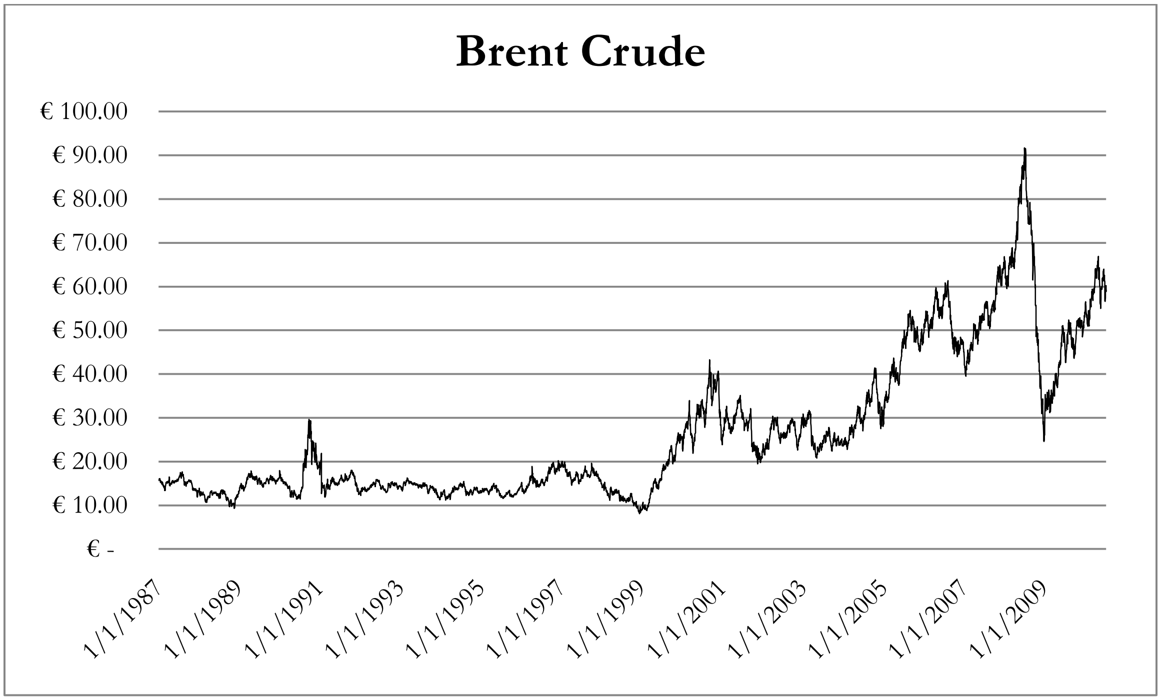
[35] (Brooks, 2008, pp. 34, 44-45)

In order to present a complete overview of the research being done in this paper, the used data will be analyzed. Since the data on the spot price of the stock, the AEX index and the crude oil price for the value analysis are on a daily basis, it is expected that the value analysis will give a more reliable result than the profitability analysis. The profitability data is on a semi-annual basis and therefore, less data will be available for the analysis, making is less reliable.

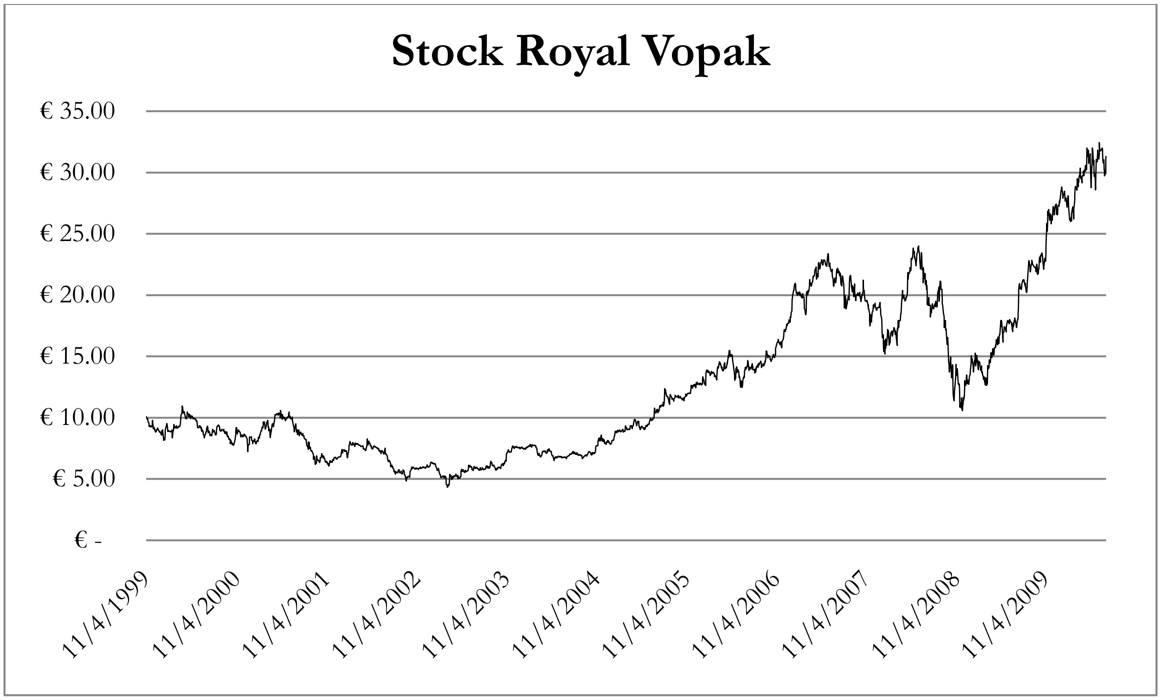


The semi-annual EBITDA of Royal Vopak N.V. does not show any unexpected patterns. Notice that in year 2001 the EBITDA shows a major downfall, which can be explained by the burst of the internet bubble. The enormous impact of the crisis also has its effect in the years succeeding 2001. From 2005 on, it shows an upward slope, except a minor dip in 2008 caused by the financial crisis.

Below, the Brent Crude oil data is shown over a longer period to give a complete overview of the data available and to better understand the price development of Brent Crude oil. Brent Crude, like most other oil qualifications, had a stable price till the late nineties. Only the year 1991 sticks out the stable prices. The year 1991 was a trying period for the oil industry. Prices rose dramatically following Iraq's invasion of Kuwait in August 1990, reaching a peak for benchmark crudes that October. But, this peak only lasted for a short period of time. The short downfall in 1999 can be explained by the quota's that were established by the OPEC to suppress the oil prices. From the year 2000, the demand for oil starts becoming stronger due to the growing world economies and the upcoming economies. A noticeable interruption is in 2001; the year characterized by the internet bubble and increases in non-OPEC production put downward pressure on prices. Due to speculations about the existing oil reserves, the prices went down in 2007, but this only lasted a short period of time. The big downfall in late 2008 is very clear. The enormous hit by the world's financial crisis affected the oil prices, causing them to drop fast.



The spot price of the stock of Royal Vopak N.V. listed on the AEX index is shown below. It shows an increase of almost three hundred percent over a period of ten years with a steady growth. A few ups and downs can be identified. Noticeable is that these fluctuations are somewhat similar movements as Brent Crude. The AEX index does not need explanation after the discussions so far. The AEX shows the strong consequences of both the internet crisis as well as the financial crisis and shows a slow upward slope in between the two crises. The slow growth characterizes the Netherland being a mature market.


Stock Royal Vopak
€ 35.00
€ 30.00
€ 25.00
€ 20.00
€ 15.00
€ 10.00
€ 5.00
€ -
11/4/1999
11/4/2000
11/4/2001
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11/4/2004
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11/4/2006
11/4/2007
11/4/2008
11/4/2009


AEX Index
800
700
600
500
400
300
200
100
0
11/4/1999
11/4/2000
11/4/2001
11/4/2002
11/4/2003
11/4/2004
11/4/2005
11/4/2006
11/4/2007
11/4/2008
11/4/2009

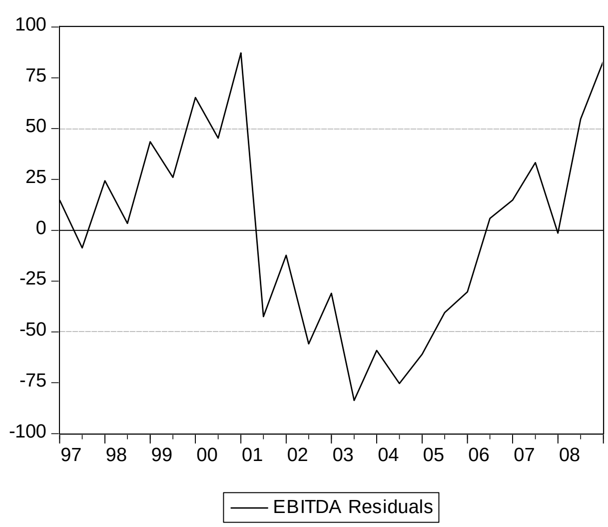
After the complete overview of the data being used, this paper used the Ordinary Least Squares linear regression to find indicators for the relation between the price of crude oil and the value of an oil terminal. For the profitability analysis, Royal Vopak N.V.'s EBITDA was used as the dependent variable and the average semi-annual price of Brent Crude as the independent variable. Notice that C(1) represents the incept and C(2) the slope coefficient for the influence of Brent Crude on EBITDA.

Dependent Variable: EBITDA
Method: Least Squares
Date: 07/16/10 Time: 15:56
Sample (adjusted): 1997S1 2009S1
Included observations: 25 after adjustments
EBITDA=C(1)+C(2)*OIL

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	201.1164	19.52698	10.29941	0.0000
C(2)	-0.113296	0.392009	-0.289012	0.7752

R-squared	0.003619	Mean dependent var	196.2640
Adjusted R-squared	-0.039702	S.D. dependent var	48.89174
S.E. of regression	49.85285	Akaike info criterion	10.73265
Sum squared resid	57162.06	Schwarz criterion	10.83016
Log likelihood	-132.1581	Hannan-Quinn criter.	10.75969
F-statistic	0.083528	Durbin-Watson stat	0.686034
Prob(F-statistic)	0.775161		

There is no evidence for a significant relation between Brent Crude and Royal Vopak N.V.'s EBITDA. To further investigate the output of the regression, one should analyze the residual plot of the regression.



This residual plot is almost similar to the graph showing the semi-annual EBITDA, implying that the regression does not have exploratory power. No evidence for a significant relation can be found and therefore the profitability analysis does not provide an indicator. This result means that there is no indication for the realtion between the price of crude oil and Royal Vopak N.V.'s profitability. This could have been expected because the EBITDA of a company is dependent of several different influences.

Then, the value analysis has to be done, and this analysis includes more than one regression. Regressing the spot price of Royal Vopak N.V.'s stock on the price of Brent Crude, is the first step in finding the potential indicator. This implies that we use the stock price of Royal Vopak N.V. as the dependent variable and the price of Brent Crude as the independent variable in the regression, giving the following output.

Dependent Variable: VOPAK
Method: Least Squares
Date: 07/16/10 Time: 15:41
Sample (adjusted): 1 2785
Included observations: 2785 after adjustments
VOPAK=C(1)+C(2)*OIL

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-1.405692	0.225619	-6.230388	0.0000
C(2)	0.348719	0.005201	67.04642	0.0000

R-squared	0.617626	Mean dependent var	12.78818
Adjusted R-squared	0.617489	S.D. dependent var	6.656648
S.E. of regression	4.116969	Akaike info criterion	5.668829
Sum squared resid	47170.27	Schwarz criterion	5.673089
Log likelihood	-7891.845	Hannan-Quinn criter.	5.670367
F-statistic	4495.222	Durbin-Watson stat	0.008553
Prob(F-statistic)	0.000000		

The regression output shows evidence for a significant influence of .3487 from the price of Brent Crude on the value of the company value of Royal Vopak N.V. These result show evidence that indicate a relation between the crude oil price and the value of an oil terminal. However, to eliminate all the doubts, a regression to control for the influence of Brent Crude on the AEX is needed. Therefore, this paper will prove that the influence of Brent Crude on the stock of Royal Vopak N.V. is substantially bigger than the influence of Brent Crude on the AEX index. The output of the regression with the AEX as dependent, and Brent Crude as independent variables is as follows.

Dependent Variable: AEX
Method: Least Squares
Date: 07/16/10 Time: 15:43
Sample (adjusted): 1 2785
Included observations: 2785 after adjustments
AEX=C(1)+C(2)*OIL

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	440.4339	6.742896	65.31821	0.0000
C(2)	-0.286153	0.155443	-1.840882	0.0657

R-squared	0.001216	Mean dependent var	428.7867
Adjusted R-squared	0.000857	S.D. dependent var	123.0936
S.E. of regression	123.0408	Akaike info criterion	12.46363
Sum squared resid	42131929	Schwarz criterion	12.46789
Log likelihood	-17353.60	Hannan-Quinn criter.	12.46516
F-statistic	3.388845	Durbin-Watson stat	0.002512
Prob(F-statistic)	0.065745		

The slope coefficient shows a negative influence. This result is not very expected. Royal Dutch Shell determines the AEX index for an important part and is very dependent on the price of crude oil. No conclusion can be drawn from this output because the coefficient is not significant at a level of significance of five percent.

Comparing the last two outputs, it becomes clear that Brent Crude indeed has a significant positive influence on the stock price of Royal Vopak N.V. At the same time, it shows that Brent Crude has an insignificant negative influence on the fluctuations of the AEX index. Since the influence of the crude oil price is obviously bigger on Royal Vopak N.V. than it is on the AEX index, this study has found an indicator. But, before the final conclusions, this paper will try to improve the model that is being used to find the indicator. Including the AEX variable into the second regression could improve quality of the model. Thus, the model will use the stock price of Royal Vopak N.V. as the dependent variable and the price of Brent Crude and the AEX index as the independent variable in the regression.

Dependent Variable: VOPAK
Method: Least Squares
Date: 07/16/10 Time: 16:02
Sample (adjusted): 1 2785
Included observations: 2785 after adjustments
VOPAK=C(1)+C(2)*OIL+C(3)*AEX

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	-0.273322	0.358087	-0.763283	0.4454
C(2)	0.347983	0.005190	67.05048	0.0000
C(3)	-0.002571	0.000633	-4.064840	0.0000

R-squared	0.619884	Mean dependent var	12.78818
Adjusted R-squared	0.619611	S.D. dependent var	6.656648
S.E. of regression	4.105535	Akaike info criterion	5.663626
Sum squared resid	46891.77	Schwarz criterion	5.670016
Log likelihood	-7883.599	Hannan-Quinn criter.	5.665933
F-statistic	2268.409	Durbin-Watson stat	0.008694
Prob(F-statistic)	0.000000		

As shown in the output, the AEX is added as a second independent variable. To test whether or not including AEX will improve the model, a Wald-test (F-test) will be performed. The Wald-test tests the null hypothesis that the AEX variable is redundant variable in this model.

Wald Test:
Equation: VOPAK_OIL_AEX

Test Statistic	Value	df	Probability
F-statistic	16.52293	(1, 2782)	0.0000
Chi-square	16.52293	1	0.0000

Null Hypothesis Summary:

Normalized Restriction (= 0)	Value	Std. Err.
C(3)	-0.002571	0.000633

Restrictions are linear in coefficients.

The Wald-test output shows that AEX is a significant additional variable in this model and it should therefore be included to improve the model used to identify the indicator. Analyzing the output of the most complete model, clear evidence for an indicator can be found. The Brent Crude coefficient is significant and shows a positive relation. This study showed that if the price of Brent Crude increases, the spot price of Royal Vopak also increases.

DISCUSSION AND CONCLUSION

A lack of academic research in the field of oil storage valuation caused this paper to be written. The purpose was to examine whether or not an indicator for a connection between the value of an oil storage facility and the price of crude oil can be identified with the ultimate goal to extend research within oil storage valuation. Royal Vopak N.V. stated that there is no relation between the value of an oil terminal and the price of crude oil. Therefore, research done within the field of LNG storage valuation could not be used to extend valuation knowledge of oil storage facilities.

This paper showed in the value analysis that there is a significant positive relation between the market value (stock) of Royal Vopak N.V. and the price of Brent Crude oil. Herewith, the paper presents an indicator for a connection between the value of an oil storage facility and the price of crude oil. First of all, this would imply that Royal Vopak N.V. ignores a very important relationship that could have a significant influence on both the valuation of the oil terminals, as well as the value of the whole company. And, more importantly, these findings could provide a base for future academic research within the field of oil storage valuation with the purpose of fulfilling the lack of knowledge. Note that the profitability analysis did not find evidence for an indicator. As stated in the methodology, this paper considers the value indicator a more powerful indication for a potential relationship then the one expected in the profitability analysis. In short, an indication for the potential relationship between the price of crude oil and the value of a oil storage facility has been found.

However, this study has its limitations that need to be named and included into the conclusion of this paper. First of all, this study only incorporated one company. Although Royal Vopak N.V. is a respected company and a perfect fit as an example in this case, including one company does not provide enough evidence to actually proof a relationship. The relation between the market value of Royal Vopak N.V. could be a coincidence within a dataset with many other oil storage companies. Second, this study has statistical limitations. Every regression showed heteroskedasticity. Under heteroskedasticity, the Ordinary Least Squares regression is still consistent, which means that the coefficients are ok. The problem with heteroskedasticity is that the possibility exists that better model

Limitations

- Data included one company
- Statistical limitations
  - Heteroskedasity
  - Serial Correlation

might be available. All the regressions showed serial correlation as well. Serial correlation means that the residual in time *t* is influenced by the residual in time *t–1*. Logically serial correlation is present is these models. All the models regression the prices of crude oil or stock. It is obvious that the price in time *t* is influenced by the price in time *t–1*, and therefore, this effect also appears in the result of the tests. Serial correlation, just as heteroskedasticity, does not affect the coefficients, and therefore the coefficients are still correct. Serial correlation does cause the standard errors of the coefficients to be biased and therefore, coefficients might appear to be significant while in fact they are insignificant. Since this study only tried to identify a indicator for a connection and not proof the actual relationship between the price of crude oil and the value of an oil storage facility, this will not cause a problem for this paper. It could cause problems for future research trying to proof the actual relationship. To avoid these problems, future research should include the return instead of prices, because returns are not influenced by the previous returns. A return on a stock could be positive on the first day, but that still does not give any information about the next day. If a stock has a price of thirty on day one, it will never drop to minus twenty the next. Return can easily be obtained using a natural logarithm. Example, the input variable should be $\ln(variable\ VOPAK)$. The natural logarithms will distribute the returns for the prices in the dataset by which it solve the problem of serial correlation. Therefore, future research should use returns instead of prices to solved these issues and get more reliable results.

It should be highlighted once more that this paper did not proof the actual relationship between the price of crude oil and the value of an oil storage facility. However, it did provide for an indication that this relationship might exists. Therefore, this paper recommends future research to investigate this relationship very thoroughly to find out whether or not it concerns a significant relationship. This should all be done with the ultimate purpose of extending the academic research in the field of oil storage valuation. If a significant relationship is proven, research within LNG could be used to easily extend the research within crude oil. Especially since LNG and crude oil show a lot of similarities. If evidence for a significant relation cannot be found, research should focus on developing valuation models for oil storage facilities that can be published so that it will provide for a new source of knowledge that is publically available.

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